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BOLLEE'S HIGH-SPEED STEAM CARRIAGE.

THE difficulties that lie in the way of constructing carriages to be run on ordinary roads by machinery sufficiently explain the slight success that has hitherto been met with in the different attempts that have been made to solve the problem, whatever the agent to which recourse has been had—steam or electricity as direct motors, or springs, compressed air, or accumulators as reservoirs of force, or, more accurately, of energy.

In fact, to speak only of mechanical difficulties, the weight of the carriage is limited by the fact that it must not form ruts in the ground that would destroy the road-bed and slacken or stop the machine's motion, or cause shocks which, in bending the different parts, would quickly lead to breakages. Finally, the machine must be able to turn in circles of very small radius and surely and quickly obey its conductor, in order to steer clear of the obstacles that it meets with at every instant on its route.

These difficulties have been happily overcome by Mr. Amédée Bollée in the steam carriage shown in perspective in Fig. 1, and in longitudinal section and plan, exhibiting the most essential arrangements, in Fig. 2.

This vehicle in no wise resembles the road locomotives that have been hitherto constructed. It is properly a steam Victoria. The boiler is located behind, and the motive apparatus in front. The water tank forms a seat for the conductor and the passengers in front. The conductor holds in his right hand the steering wheel, which acts upon the wheels of the fore-carriage, while with his left hand he maneuvers the stop-valve. When it is desired to change direction, the right hand lets go of the steering wheel and seizes the lever of a Stephenson link-motion, while the left hand is substituted for the right for maneuvering the steering arrangement.

The boiler consists of a Field vertical generator, 1·8 meters in height and 58 centimeters in external diameter, and containing 102 copper tubes 45 centimeters in length and 22 millimeters in internal diameter. The circulatory tubes which penetrate these latter are 40 centimeters in length, 16 millimeters in diameter, and 1 millimeter in thickness. The shell of the boiler is of steel plate, and carries two safety-valves and one Bourdon pressure-gauge. Its total capacity is 228 liters. When the water is at the normal level, the boiler contains 71 liters of water and 157 of steam, or about one-third water and two-thirds steam.

The supply is secured through a Koerting injector and a pump. The boiler is registered at 10 kilogrammes per square centimeter, and runs normally at that pressure. It takes from thirty to forty minutes to put it under pressure, but it is easy, when need be, to attain the desired pressure in less than twenty minutes. As the escape of steam occurs at the lower part of the chimney (Fig 2), the jet is not seen externally, and no noise is heard during the machine's running.

The motor, properly so called, consists of two vertical cylinders arranged in a boiler plate box so as to protect them from dust. Motion is transmitted to the hind wheels by a system of gearings and endless chains.

The Stephenson link-motion is capable of taking four positions, which correspond to detents of ¾, ⅝, ½, and ¼.

The normal speed is 20 kilometers per hour on a level.

The carriage weighs in all 2,180 kilogrammes, which is thus distributed: 1,030 kilogrammes upon the fore wheels and 1,150 upon the hind ones.

The consumption of coal varies between 1 and 3 kilogrammes per kilometer, that of water between 8 and 10 liters, and the work effectively developed at the rim of the wheels may be estimated at 7 or 8 H. P. As the tank contains 390 liters of water, a run of 25 or 30 kilometers may be made without replenishing it.

The frame of the vehicle likewise exhibits some interesting arrangements. The two hind wheels are loose upon their common axle, and support the hind-carriage through the intermedium of two springs. The fore wheels are independent of each other, and are fixed upon two different axles that are each capable of revolving around a vertical axis. Owing to these arrangements, the vehicle possesses a certainty and ease of evolution that has not hitherto been attained.

The wheels have wooden rims and spokes and bronze hubs. Those of the fore-carriage are 80 centimeters in diameter, and those of the back 1·05 meters.

Each fore wheel pivots around its vertical axis like the wheel of a velocipede. On maneuvering the steering wheel, they move together obliquely, but not at the same angle, this being a necessary condition for directing the machine. A second advantage results from the independence of the axles, and that is that the suppression of a single axle for the two fore wheels does away also with the lever at whose extremity the stresses exerted by the ground would render the muscular power of the conductor insufficient.

Above the steering wheel (Fig. 2) there will be observed a hand-wheel of smaller diameter. This is designed to actuate an ordinary block-brake, which acts against the hind wheels. Such are the principal arrangements of the steam carriage constructed by Mr. Bollée and studied experimentally by a commission from the Committee on Mechanics of the Industrial Society of Mulhouse.

The note published by this commission concludes by rejecting the claims of a carriage of this kind for public use, without, however, desiring to influence private parties who might find it convenient to use it. The high price of the machine, however, and the great expense of keeping it in repair and managing it are of a nature to circumscribe the applications of the system.

The Messrs. Koechlin have recently made a few modifications in the construction of this carriage, and are still studying a means of solving the difficult problem connected with the obtaining of complete security therein.—*La Nature.*

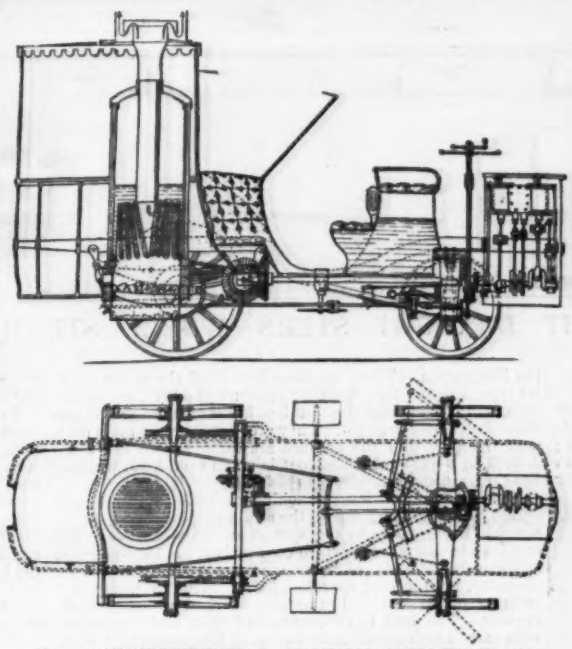


FIG. 2.—LONGITUDINAL SECTION AND PLAN OF THE CARRIAGE.

FIG. 1.—IMPROVED HIGH-SPEED STEAM CARRIAGE.

CHINA has a bridge at Langang, over an arm of the China Sea, some five miles long, with 300 arches; over the pillar of each arch reclines a lion 21 feet long, made of one block of marble. The roadway is 70 feet wide.

PREVENTING THE CRACKING OF FIRE-CLAY RETORTS.

IN a communication submitted to the Congress of the Société Technique de l'Industrie du Gaz en France, M. Meizel describes the method in use at St Etienne for preventing the cracking and breaking of gas-retorts when the settings are lighted up. He observes that when a setting of completely new retorts is fired, it frequently happens that after only a few days' working one or several of the retorts will be found cracked transversely not far from the mouthpiece. These accidents occurred very frequently at St. Etienne, notwithstanding all the precautions taken at the time of lighting up; and consequently M. Meizel was led to inquire whether the breakages were caused by something besides the firing. When starting a stack of twelve settings, for example, it was customary to begin at both ends and proceed toward the middle, with a view to save as much heat as possible; the front wall being continuous from benches 1 to 6. In examining the settings not fired, but contiguous to those in working, the author noticed many retorts showing cracks similar to those already mentioned. These observations, many times repeated, and taken into consideration with the nature of the cracks, led M. Meizel to the following conclusion respecting their cause. Supposing that the end setting is fired up, the heat expands the front wall, and this expansion makes itself felt all over this wall. The retorts in the next (unfired) bench nearest the source of heat are consequently subjected to a bending strain acting through the front wall upon the mouthpiece, while the rest of their length is embedded in solid masonry, and therefore cannot yield. It is not to be wondered at, under these circumstances, that a transverse crack is the result. If this theory is correct, it would be sufficient, in order to prevent these leaks, that the expansion of the heated front wall of one bench should not extend to the next. Accordingly, it has been the practice at St. Etienne only to finish building the front walls of the two end settings of every stack, the bricks necessary to close up the wall between the side retorts and the piers of the adjacent benches being left out until their turn comes for firing. When the settings are to be set in work, the front walls are bricked up as usual, and the ascension-pipes are fixed. Consequently, the brickwork of the hot bench is fully expanded before it is directly connected with its neighbors. The practical results of this system are that, during the seven years ending 1877, of 1,000 new retorts fixed for the first time, 284, or say 28 per cent., were found to be broken in the manner described. From 1878 to 1882 inclusive, 66 settings, containing 528 new retorts, have been fired on the improved system, of which only 14, or 2·65 per cent., were afterward found injured in the same manner.

NEW TESTING MACHINE.

PROFESSOR BOCK, of the Leoben School of Mines, has devised a testing machine, in which the sample is inserted vertically, its upper end being attached to a cross-beam in connection with a strong screw. This screw is made to rise by causing the nut to revolve, by means of spur-gear, in such a manner as to exert a tensile strain on the sample. The lower end of the sample is also attached to a cross-beam, which transmits the strain to the short arm of a steelyard, the long arm of which is connected, by a vertical rod or link, to a second steelyard placed above the first. A weight is made to slide along the long arm of the second steelyard, thus counterbalancing a predetermined strain exerted on the sample. The machine is also provided with means for measuring torsional and shearing strain, as well as that of tension.

THE NEW ALCATRAZ BELL.

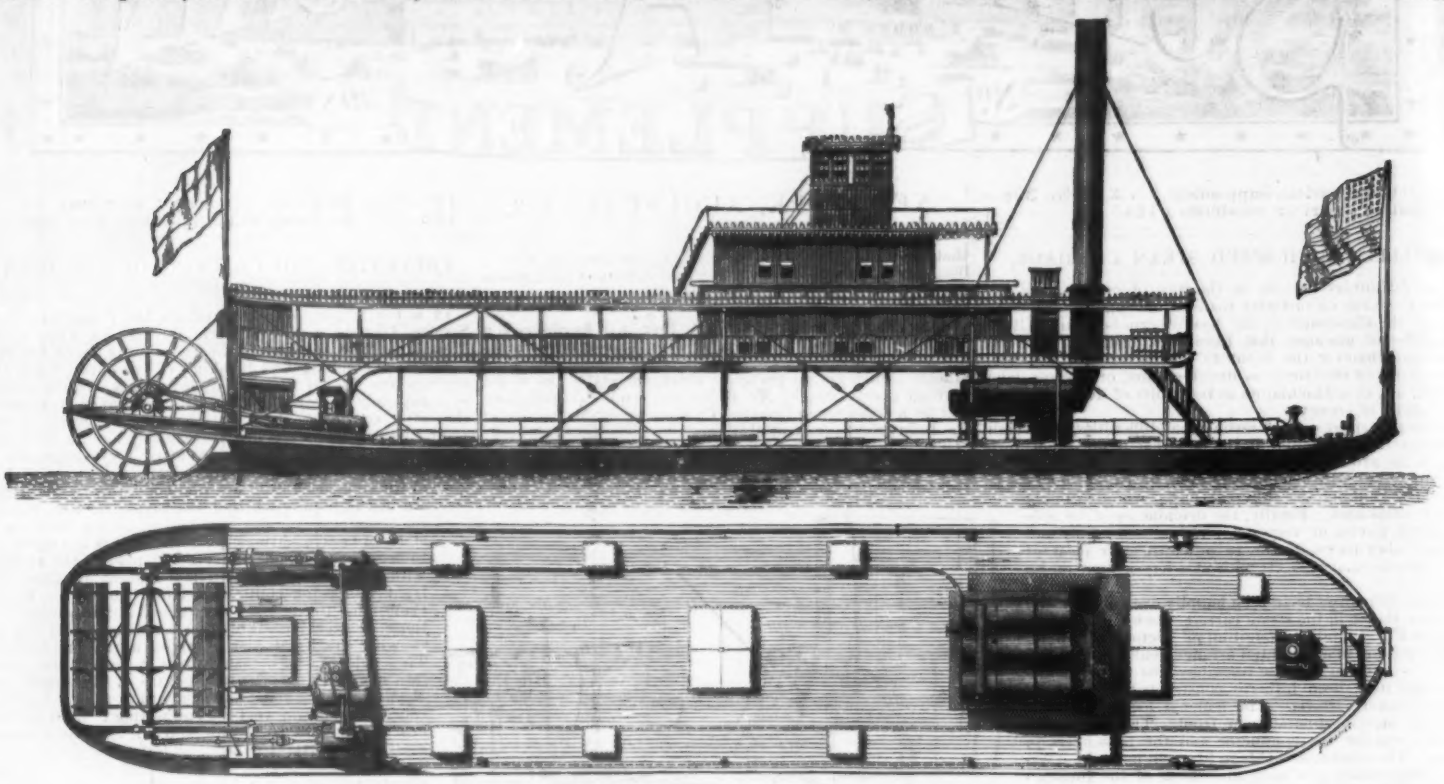
THERE was recently cast at the foundry at Mare Island navy-yard a fog bell for the lighthouse station at Alcatraz Island, which, as a piece of workmanship, is attracting much attention. It is claimed to be the largest bell that has been cast on the Pacific coast. The dimensions are as follows: Weight, 3,333 pounds; diameter of bell at the mouth, 4 feet 7 inches; diameter at the crown, 2 feet 3½ inches; thickness of sound bow where clapper strikes, 4 inches. Key note, D. The tone is loud and remarkably melodious. The tolling of the bell will be done by machinery. The material of which the bell metal was composed was the melting of three condemned boat howitzers, a condemned fog bell worn out in service, the balance being new material of copper and tin, the proportion being one part of tin to four parts of copper.

LIGHT DRAUGHT STERN WHEEL STEAMER.

WE give an engraving of a stern wheel steamer recently completed by Messrs. Yarrow & Co., of Poplar, for the navigation of the river Magdalena, in the United States of Colombia. It is generally known this firm has already built a large number of vessels of this type; they have been attended with very marked success.

The *Engineer* states: As a matter of fact, Messrs. Yarrow have obtained a speed of thirteen miles an hour in vessels 120 ft. in length by 24 ft. beam, having a draught of 12 in.; and a speed of fifteen miles an hour in vessels 130 ft. in length by 28 ft. beam on a draught of 15 in. Our engraving illustrates one of the largest of this type of vessel which Messrs. Yarrow & Co. have hitherto constructed. The dimensions, exclusive of the wheel, are 150 ft. in length by 31 ft. beam, with an estimated draught line of 15 in., and it is confidently expected a speed of sixteen miles an hour will be obtained. The general design will be clearly seen from the illustration. There are three boilers of the return tubular type, adapted for a working pressure of 140 lb. per square inch, and of sufficient size and heating surface to give steam without a forced draught. They are placed on the main deck near the bow, and the engines are quite aft, on the usual American plan, so that the boat is on an even keel, whether light or loaded.

This disposition of the machinery admits of a very light design of hull being made, the strain of these overhanging weights being taken by the system of diagonal ties. The engines are compound surface condensing, the high-pressure cylinder being 20 in. diameter, and the low-pressure 33 in. diameter, both having a stroke of 5 ft. The air pump, circulating pump, and feed pumps are worked by independent engines. The hull is throughout of steel, and is provided with three longitudinal bulkheads and five transverse bulkheads, subdividing the boat into twenty-four compartments. The cargo is carried on and below the main deck, and on the upper deck is the passenger accommodation. In comparing the efficiency of stern wheel boats with side wheel boats, we may remark that actual experience tends to show that with the same dimensions, displacement, and power, the stern wheel gives a little better result in point of speed.



LIGHT DRAUGHT STERN WHEEL STEAMER.

DEEP-SEA SOUNDINGS.

THE long voyage made in the interests of science a few years since by the Challenger, a ship of the British service, awakened a widespread desire upon the part of intelligent readers in all portions of the world to learn something further concerning that wide and mysterious domain, the bottom of the sea.

The report made by the U. S. steamship G. S. Blake, upon her return in February from a somewhat similar mission, has renewed this feeling. In the mean time, it will interest the reader to learn why we should trouble ourselves as a nation as to the exact conditions existing in the subaqueous world.

Our artist in making a visit to the Blake found her moored to a wharf at the Brooklyn Navy Yard, and upon explaining the nature of his errand was afforded, through the hospitable courtesy of the officers present, a full insight into the subtle methods employed in obtaining accurate results of the costly tours of research to which they are assigned.

The Blake is, in point of fact, a floating laboratory. The vessel itself, shown in our illustration on the opposite page, is a staunch little craft, riding out Atlantic storms like a duck, and in every way adapted to the peculiar service to which she is dedicated. She is schooner-rigged, carries four boats, and would pass, were it not for certain accessories, for a roomy private yacht. These additions are mainly a heavy boom rigged forward and pivoting upon

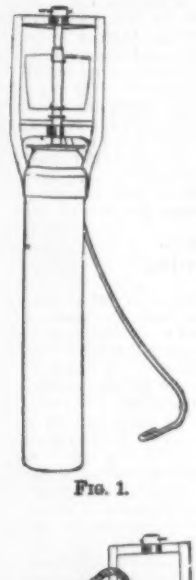


FIG. 1.

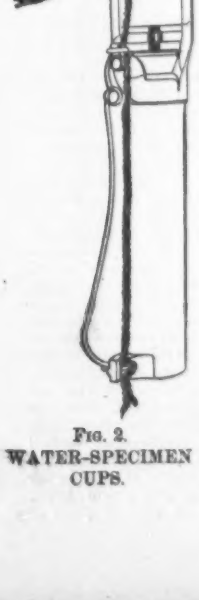


FIG. 2.
WATER-SPECIMEN CUPS.

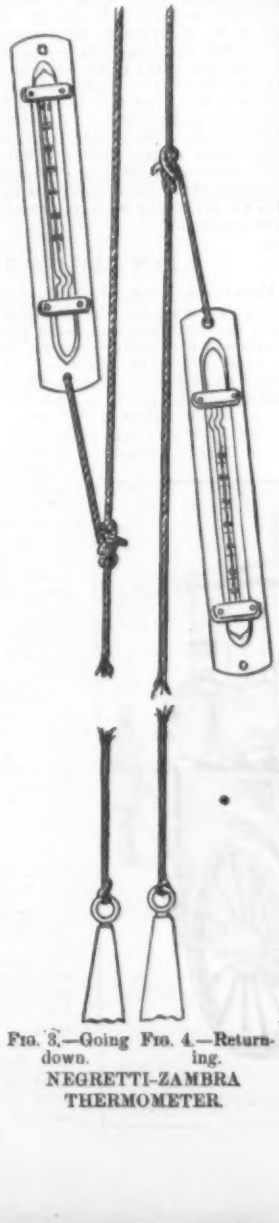


FIG. 3.—Going down. FIG. 4.—Returning.
NEGRETTI-ZAMBRA THERMOMETER.

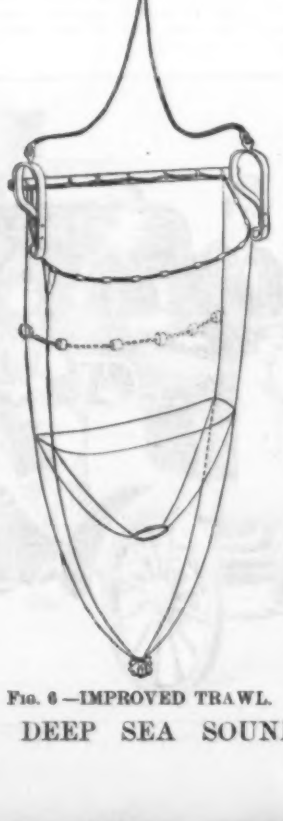


FIG. 6.—IMPROVED TRAWL.

FIG. 5.—MILLER-CASELLA THERMOMETER.

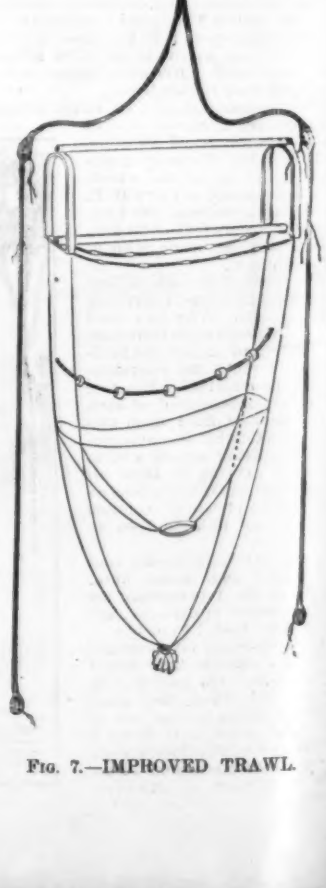


FIG. 7.—IMPROVED TRAWL.

DEEP SEA SOUNDINGS.

the foremast, and a high framework over the port bow. The former is used in handling the trawl, and the latter is the complex and delicate reel and its belongings, by which the miles of wire are paid out or wound in during soundings. This device is the invention of Lieutenant-Commander Charles D. Sigsbee, U. S. N., formerly commander of the Blake, and the author of an elaborate work upon "Deep-Sea Sounding and Dredging," which has been published by the Government.

Below decks a large proportion of the space, aside from the officers' quarters, is given over to the draughting room, laboratory, and storage rooms. Every minute particle brought up during a haul is preserved and labeled. The most exact conditions under which each day's work is prosecuted are recorded, and the reports present a minute history of each trip.

To the ordinary investigator much of this painstaking labor seems wasted, but a little reflection reveals the great utility of all this care. An example is afforded by the results of the first two years of Lieutenant-Commander Sigsbee's work upon the Blake (1875–76), which were devoted to the Gulf of Mexico. In his own words, "The execution of the work embraced observations of depths, serial water temperatures and densities, and for currents when possible, together with the collection of specimens of the bottom soil and deposit, and of surface, bottom, and intermedial water specimens," all of which served to add vastly to the sum of human knowledge regarding that vast and capricious basin.

It would be impossible within the limits of a single newspaper article to give the reader an adequate idea of the many delicate and ingenious devices used upon the Blake in the operations of her expert officers. A few of the more important may, however, with the assistance of the illustrations, admit of explanation.

The leading mechanism is the reel and its belongings, to which reference has already been made. The reel proper takes up, in the first layer of wire, exactly one fathom in each revolution. A tabulated calculation gives the exact increase of wire laid on by each revolution due to overlapping; for, evidently, the second one thousand revolutions will show a considerable increase of wire above the first one thousand. A register upon the axle records the exact number of revolutions.

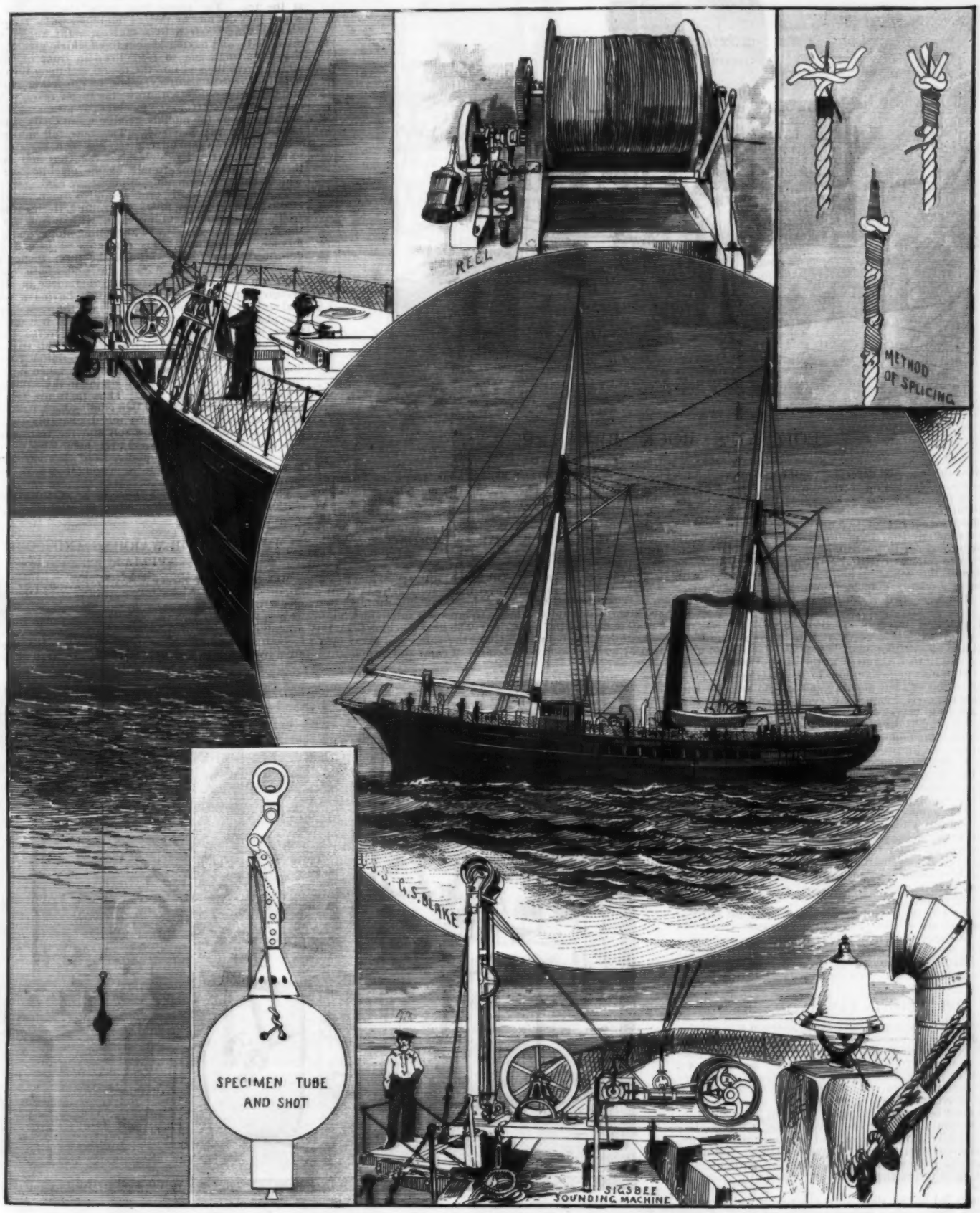
A reeling in or strain pulley, and an accumulator, the latter consisting of tubes containing spiral extension springs, serve the important purpose of checking undue speed and overcoming the great strain sometimes occasioned by the pitching of the ship. A swivel pulley admits of reeling in while the vessel is steaming ahead. There are also many minor devices connected with this admirable invention, the whole being recognized as the most effective machine of the kind in use.

Fine piano wire is used for sounding. The tube which serves to inclose specimens of the bottom is weighted by a heavy shot, having a hole through its center, into which the tube fits loosely. By a neat trigger arrangement the shot is dropped upon reaching the bottom, thus easing the strain in bringing up the tube and its contents.

Ingenious water-specimen cups (see Figs. 1 and 2), which admit and retain sea water at any depth, and thermometers of the most delicate character, are used. Of the latter two kinds are employed, one being the Negretti Zambra (Figs. 3 and 4), in which the mercury is cut off by a kink or trap in its glass tube by reversal when stopped at any given depth; and the other, known as the Miller-Casella (Fig. 5), which registers temperature by leaving a minute colored float at the highest point when the mercury retires. Electric means are now employed successfully to indicate to the operators the conditions at any depth to which the instruments have reached.

Next in order of importance stands the trawl, of which the outline is shown in Figs 6 and 7. This is covered by a net. In dragging, the steamer travels backward. All contents brought up by the trawl are carefully examined and classified. Mops or tails are sometimes attached, which catch up many forms of shells and other minute objects which would escape the net. These are technically called tangles.

All of the foregoing inventions have been perfected after years of patient and laborious experiment. The future

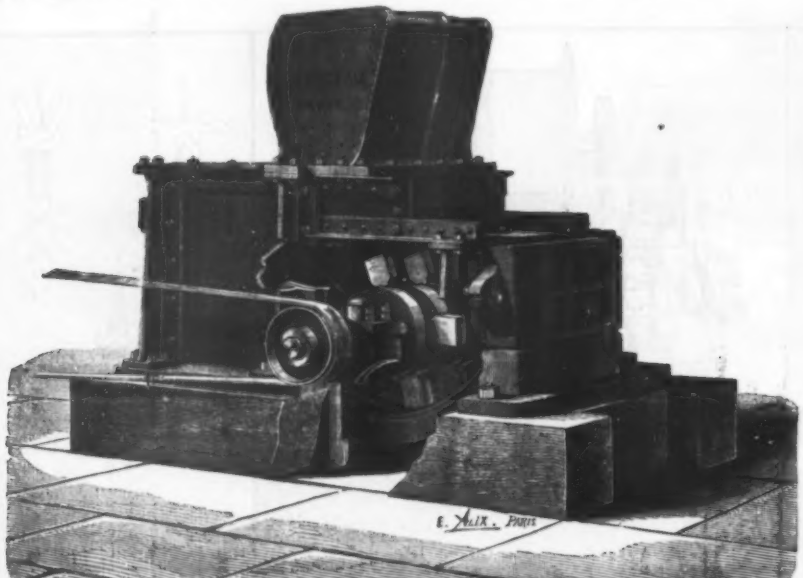


DEEP SEA SOUNDINGS.—THE STEAMSHIP G. S. BLAKE AND HER APPARATUS.

promises to yield up to us many as yet undreamed of mysteries of the sea, due to the inventive ability of the eminent workers in this fascinating field of research. For the foregoing particulars and also for the engravings we are indebted to the *Mechanical News*.

LOIZEAU'S ROCK BREAKER FOR MAKING MASONRY SAND.

THE difficulty that is experienced during the course of some works in procuring river or other sand, and the necessity of providing numbers of horses and carts, with drivers, to transport it, have led engineers to manufacture *in situ* the



LOIZEAU'S ROCK BREAKER.

quantity of this material necessary for their purposes. Such manufacture is carried on very economically and with the greatest facility by means of the apparatus shown in the annexed cut.

The machine consists of two distinct parts, to wit:

1. Of a rigid cast iron frame that carries at its upper part a hopper into which is introduced the stones to be broken up, and lined internally with two strong steel gratings, one inclined and the other curved, and both provided with apertures of a specific diameter in order to allow of the passage of the sand that results from the breaking of the stone.

2. Of a breaker, properly so called, formed of disks traversed by steel axles that serve to hold movable hammers, each weighing 9 kilogrammes. These disks are keyed upon a driving shaft that revolves at the rate of 900 times per minute and transmits its motion to the hammers. These latter, by reason of their mobility and of the velocity with which they are carried along, are kept constantly extended at right angles to the axles.

This granted, it is easy to understand that the stone introduced through the hopper will be immediately broken up by the hammers and thrown against the gratings, which latter will allow the fragments of proper size to pass through them. The pieces that are not broken sufficiently small pass under the hammers again and are still further reduced in size. These different phases of the operation are extremely rapid. If the hammers happen to strike a stone that offers more than ordinary resistance, they oscillate upon their axes, so as to avoid breakage and to reduce to a minimum the motive power necessary for the operation.

The sand produced by this machine always possesses angular and very resistant grains, seeing that the rocks are not submitted to that crushing action that they are in ordinary rock-crushers, mills, etc.

We may state, in conclusion, that the principal parts of this apparatus are of steel, and that the hammers have two striking surfaces, thus permitting of their duration being doubled by reversing them, and that they may be quickly replaced by others without the necessity of taking the apparatus apart.—*Les Annales des Travaux Publics.*

IMPROVED TIN CAN MACHINERY.

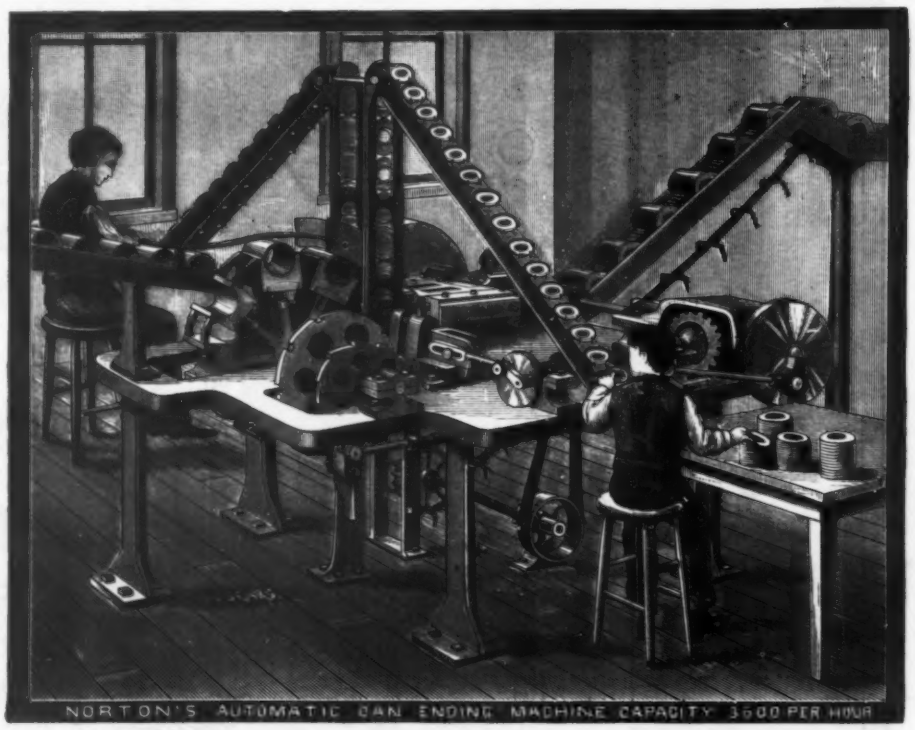
THE growth of the preserved food industry in this country has been so rapid and so enormous that great difficulty has been experienced by the tin can makers in keeping pace with the demand for their goods. This has imposed upon inventors the task of studying out novel forms of machinery to assist the manufacturers in producing the cans; a task that is rendered peculiarly difficult owing to the fact that the cans must be not only fitted but soldered by mechanism. Messrs. Norton Bros., 40 to 46 River Street, Chicago, Ill., have at last solved the problem, and they now manufacture tin can machinery that seems to be well nigh perfect in all the details of its operation. The following particulars of the working of the mechanism we derive from the *American Machinist:*

The tin is fed in the sheet into a machine which cuts it into bodies, thence into a second machine which discharges the body, seamed up ready for soldering; next the side seams are soldered at the rate of 50 per minute by a very simple machine; thence the bodies pass into an automatic machine where they meet the tops and bottoms, fed down through chutes or hoppers, and they emerge at the bottom of this machine into an elevator with the ends put firmly on ready for the soldering.

It must be remembered that cans to be used for the purpose of "processing" (that is, having the article to be canned "hermetically sealed") must be absolutely perfect —must be, in fact, miniature steam boilers. The mouth of each can being closed airtight, two rows of cans are carried along automatically up an inclined track and then down into a long tank filled with boiling hot water submerging the cans. The heat of the water expands the air confined in the can, and if there are any holes, no matter how small, the air escaping causes bubbles to rise in the water, which being seen by the inspector as the cans pass him leaving the tank, he removes the defective one, the finished cans passing from the testing tank through heated troughs as fast as they can roll on their way to the warehouse or to the packing room, emerging dry. From the time the tin in sheet form enters the first machine, it is kept continuously on its travels until it rolls into the warehouse ready to receive its contents. It is here that the great saving of labor occurs, the operation being continuous, and requiring the attention of but a few unskilled boys to produce a great number of cans daily.

The capacity of the machine which solders the tops and bottoms is from 2,500 to 7,500 per hour, according to the diameter of the cans. The range of the machines is from the ordinary 1-pound salmon can to the gallon fruit can, and quickly changed from one size to another. The uniform size of the cans made by this system permits close fitting ends, which effects quite a saving in solder over those made by hand, while the saving of labor is as six to one over hand-work.

The ends of the cans are cut in the ordinary manner, and brought to the can-making department in large trays (shown in the cut below). The tin for the bodies is fed into the first machine, which automatically squares and subdivides it into bodies of exactly the right size. The next machine turns the locks, forms the body, and closes the side seam, being operated by an ingenious arrangement of cams and levers.



The next step in the operation is the soldering of the side seams. This is done by means of an endless chain carrier, each link of which carries a can body forward, first through a bath of flux, then up an incline which drains it out, thence through a bath of molten solder, the can body being carried by means of the links on a track shaped so that only the circular portion containing the grooved seam is immersed in the solder. As the cans leave the bath, they are carried up a sharp incline, which causes the molten solder to flow out, and the can then passes through a funnel, which rounds it up and supports it, while asbestos wipers, arranged below to bear against the seam, wipe off all the surplus solder into a box below placed to receive it. The cans are then carried forward over blasts of air, which cool and set the solder. The capacity of this machine is fifty side seams per minute, large or small, the larger-sized cans filling the chain, and delivering a continuous stream of finished seams.

The body having now been made and soldered, the next step is so assemble the body and the top and bottom. The cut fully shows this operation. Elevators made upon the link chain pattern raise the can bodies from the side seam soldering machine into the feed spout of the ending machine, which consists of an intermittently revolving turret, having a series of half moulds on its periphery. These, as the turret revolves, take up successively one body after another, a curved guard retaining them until they reach the bed-plate of the machine, where they register accurately with a corresponding half mould, which is mounted on a reciprocating crosshead and driven by means of cams from the main shaft of the machine. At the point where the moulds meet are vertical feed hoppers for the ends, which, being carried up by endless belts, are fed into these hoppers at the top. The heads feed down singly to the mould, where they are met by pistons mounted on a reciprocating crosshead and driven by a shaft at right angles with the main shaft, and having slotted links which give the proper time for a single end to feed down in front of the piston, which forces the end into the mould and upon the can body with the greatest accuracy. The reciprocating half mould and the pistons then withdraw, the turret revolves, and the cans are expelled from the machine by means of extractors working inside the moulds striking a stationary cam on the bed-plate of the machine. The cans fall into a trough, whence they roll into an endless link belt elevator, similar to the one described, which raises the cans and discharges them into the feeding trough of the machine (see figures) which solders the top and bottom of the cans.

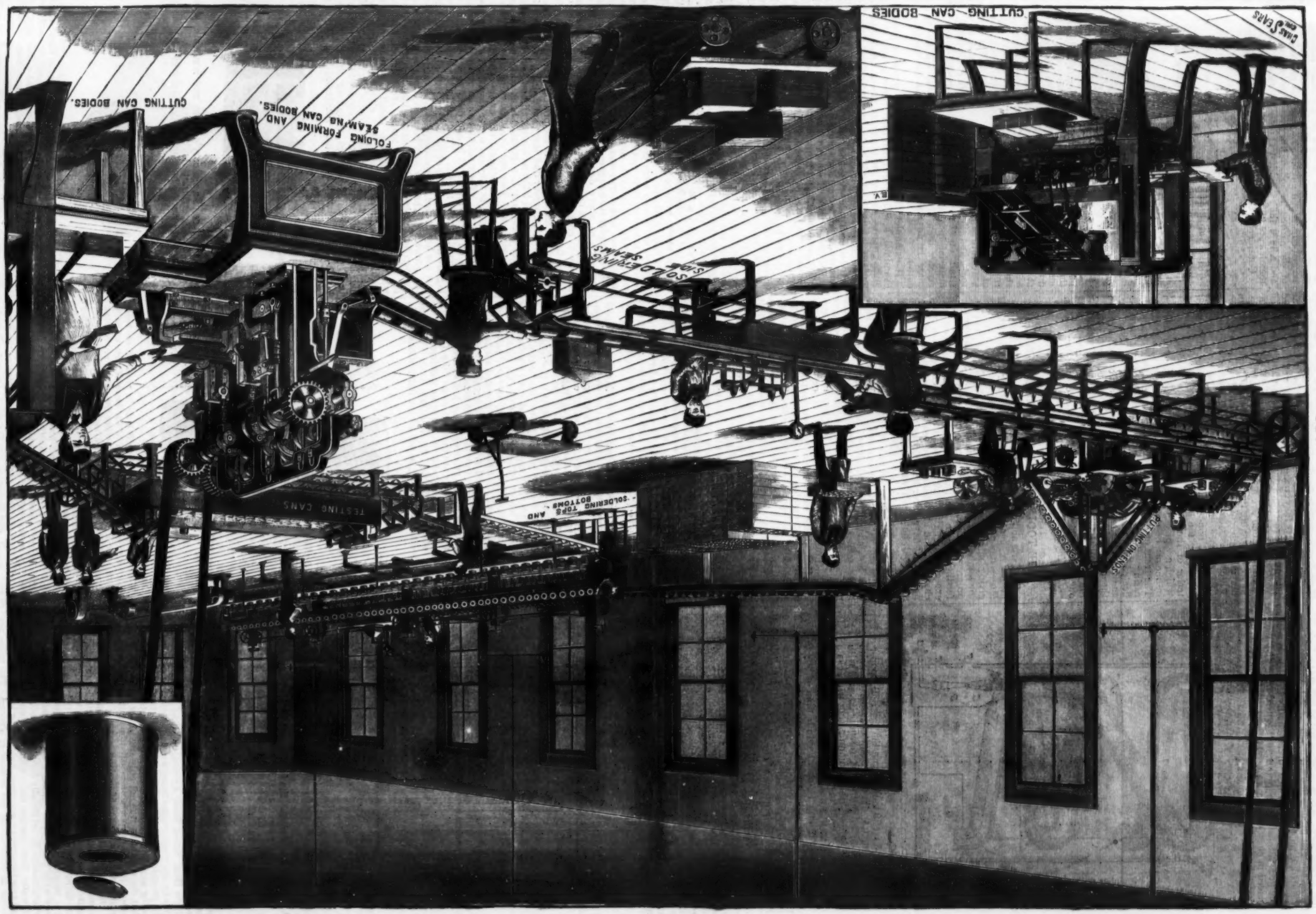
This machine consists of a double track, having two chains supported on idlers for rolling the cans along by friction; a heating plate, provided with means for heating the ends of the cans as they are rolling along, and a bath of flux and a solder bath. The cans are first heated, as above described; then passed through the flux; thence through the solder bath. As they leave the solder bath, one of the most simple and yet interesting appliances in the whole system is brought into use, viz., a tube having a projection and springs for turning the can into the vertical position, and placing it on its end on an endless belt beneath the solder bath, which carries the can back to the end of the machine where it first entered. During this trip they are subjected to cooling blasts, and at the terminus the cans are delivered on a table, whence they are taken up and put through the other side of the machine in the same manner, which solders the other end. Thus there are two streams of cans rolling forward and two coming back below, carried on the cooling belts, the last one discharging the finished cans on a trough, where they roll into the testing machine. The advantages of this system over hand labor are that the cans are more uniform in quality; and they have proved to be stronger under all tests to which they have been subjected.

The rapidity with which they can be manufactured is remarkable, thus tending to equalize the supply and demand.

IMPROVED AIR-WARMING AND COOLING APPLIANCES.

MESSRS. ROBERT BOYLE & SON have recently effected some important improvements in air-warming and cooling arrangements, which we have no doubt will prove of considerable value as a simple, and at the same time economical, means of providing a supply of fresh air at such a temperature as will be both safe and agreeable in all seasons of the year. The air-warmer is intended for warming the fresh air supply to a building where hot air, water, or steam pipes are not available. The arrangement consists of a copper or iron pipe about 1½ in. diameter, placed in an inlet tube, preferably of the form of a bracket. This pipe is made of zigzag shape so as to cross and recross the tube from top to bottom, causing the incoming air to repeatedly impinge upon it in its passage through the tube. At the bottom of the tube an airtight chamber, so far as the interior of the tube is concerned, is fixed, in which a Bunsen burner is placed, the flame of which plays up into one end of the pipe which is connected with the top of the chamber. The heat travels through the entire length of the pipe, the other end of which may be made to either dip into a condensation box in the bottom of the tube, or be continued, as shown by dotted lines in the accompanying diagram, up into the flue or extraction shaft. If the pipe terminates in the box, the vapor is condensed there and carried off through outside

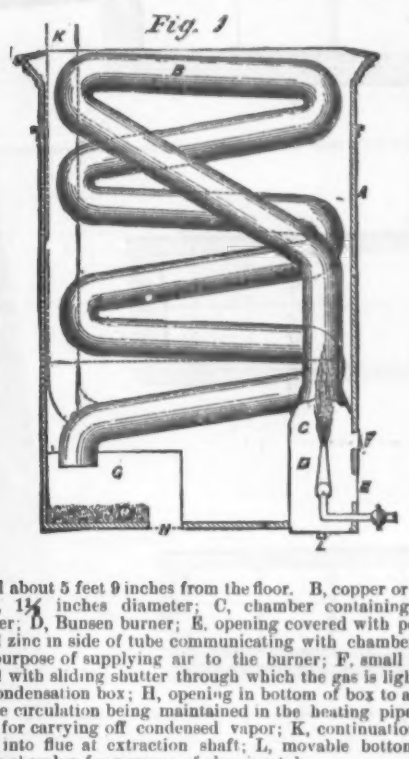
NORTON'S IMPROVED AUTOMATIC MACHINERY FOR MAKING TIN CANS.



wall by means of a small pipe; and any products of combustion which may arise are absorbed and rendered innocuous by passing through a loose bed of charcoal which covers the bottom of the box. The charcoal should be renewed about once a fortnight or month, according to the extent the tube is used. The diagram below (Fig. 1) shows the arrangement, which is explained as follows:

A, air inlet tube or bracket made of galvanized iron and painted, dimensions 44 inches by 16 inches by 6 inches. These tubes can be treated ornamentally to harmonize with the decorations of the rooms, and where necessary may be placed in chases in the wall. The top of the tube should

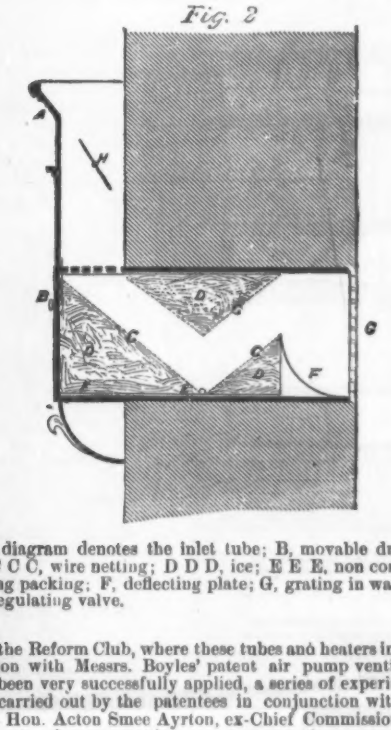
Fig. 1



stand about 5 feet 9 inches from the floor. B, copper or iron tube, 1¼ inches diameter; C, chamber containing the burner; D, Bunsen burner; E, opening covered with perforated zinc in side of tube communicating with chamber for the purpose of supplying air to the burner; F, small hole fitted with sliding shutter through which the gas is lighted; G, condensation box; H, opening in bottom of box to allow of the circulation being maintained in the heating pipe; J, pipe for carrying off condensed vapor; K, continuation of pipe into flue at extraction shaft; L, movable bottom to flame-chamber for purpose of cleaning tube.

Where the tubes are placed against woodwork all chance of fire may be avoided by fitting them with a double casing or jacket, and filling in the space between with asbestos or other non-conducting material. With this arrangement the air supply can be raised from a temperature of 30° to 130°, and to show that it is one of the most economical methods of heating in existence, it is only necessary to mention that the cost of gas consumed to raise the incoming air from a temperature of 40° to 100° is less than one farthing per hour, this being effected with the air passing through the tube at a velocity of 300 feet per minute, or 18,000 feet per hour.

Fig. 2



A in diagram denotes the inlet tube; B, movable drawer; C C C, wire netting; D D D, ice; E E E, non conducting packing; F, deflecting plate; G, grating in wall; H, regulating valve.

At the Reform Club, where these tubes and heaters in combination with Messrs. Boyles' patent air pump ventilators have been very successfully applied, a series of experiments were carried out by the patentees in conjunction with the Right Hon. Acton Smee Ayrton, ex-Chief Commissioner of Works, to whose suggestions we may mention, *en passant*, the patentees are indebted for some important improvements in the apparatus. The results of these tests demonstrated that the apparatus was not only useful for warming the air supply for the purposes of ventilation, but that it might be used as the sole means of heating rooms.

On testing the tubes with the anemometer the air was found to be passing in at the rate of 16,000 cubic feet per hour, the dimensions of the tube being 24 by 16 by 6 inches, one-third of which was blocked up with the heating pipes. It is important to note that the figures compare more favorably with the results obtained by elaborate and expensive arrangements for artificially forcing air into a room by means of water, fans, sprays, etc., which are not only expensive and troublesome to maintain, but, owing to their bulk, constitute an obstruction and eyesore in a room. The tubes are fitted with regulating valve and deflecting shields to prevent the air from discoloring the walls. They can also be fitted with an arrangement for filtering and freeing the incoming air from blacks and dust. They are not expensive, the price of them ranging from 45s. to 100s., according to size and material used.

They are applied to a number of buildings, including the Guildhall and Lloyd's, Royal Exchange, and have been found to answer exceedingly well. The great objection to nearly all methods of admitting fresh air is the disagreeable cold draughts they create. The appliance we have described effectually overcomes this, and should therefore be welcomed as a really valuable addition to the list of useful sanitary inventions which are now in use. Fig. 2 shows the arrangement for cooling the air in hot weather. It consists of an air inlet-tube of bracket form, made of iron. The part which penetrates the hole in the wall has an outer casing, so that a space of about ½ inch is left, between which is packed a non-conducting substance for the purpose of preventing the heat from the wall penetrating into the interior of the opening, and acting upon the blocks of ice, which are placed in a movable drawer, and kept in position by means of open galvanized iron or copper wire netting. The front of the drawer is also double, and packed same as casing. The outer air entering through the grating is deflected by a metal shield on to the suspended blocks of ice, and from thence on to the ice at the bottom of drawers and thence up the tube into the room, it being not only cooled, but purified thoroughly, from blacks, dust, etc. This arrangement, we should say, would prove very acceptable in our fashionable London drawing-rooms during the season. —*Building News.*

THE TOOLS OF THE PYRAMID BUILDERS.

THE arts and civilization of the early Egyptians have furnished a theme to writers and travelers from the time of Moses downward, and scores of books have been written giving minute descriptions of the pyramids, the temples, the tombs, and the ruined cities that attest the wonderful progress of a people who, situated in a land of overflowing fertility, where the burden of procuring a livelihood was exceedingly light, were able to turn their energy into other channels, and more than 4,000 years ago produced achievements that have never been rivaled. All this has been told and retold, but when we inquire how these architectural feats were performed, how the stone was quarried, transported, carved, and raised into its place, authors are silent, or else talk mysteriously about mechanical powers that have been lost, and the superiority of the ancients over us even in the matter in which we pride ourselves the most. The fact is, that few men who have studied Egyptology have been fitted by their previous training to investigate mechanical processes, or from a number of scattered fragments to arrive at the nature and construction of the tools employed; and Egyptologists in general have been too fully occupied by the more seductive study of the language and social customs of the people to give any attention to these matters. Hence it is that until quite recently we have had but very vague ideas upon the means employed by the builders and masons of the pyramids. A recent investigator, however, Mr. W. M. Flinders Petrie, has brought a sudden accession to our stock of knowledge, and by careful observation and the collection of a number of samples, mostly half finished articles damaged and rejected in manufacture, he has arrived at the most unexpected and startling conclusion that the hard stones employed by the Egyptians, the diorite, basalt, and granite, were cut with jewel-pointed tools, used in the forms of straight and circular saws, solid and tubular drills, and graving tools, while the softer stones were picked, and brought to true planes by the aid of trial or face plates.

Mr. Petrie has embodied the results of his novel and most interesting researches in a paper read before the Anthropological Institute; and on this we have drawn for the following account of the specimens and results, which will also be described in Mr. Petrie's forthcoming volume on "The Pyramids and Temples of Gizeh."

The first and most important point is that the principle of action of the tools was by plowing out the stone by fixed cutters, as in a planing machine; and not by grinding, as with a lapidary's wheel. The proofs of this are that the cut surfaces do not show a smooth ground surface, as a stone sliced with diamond dust does, but a grooved surface, like freestone cut by a toothed saw, or like rough sawn timber. And that this grooving is not due to the action of any loose powder is proved by the grooves being just as deep in hard stone (like quartz) as they are in softer stone (like feldspar), where both occur side by side in the same specimen. Two examples of this grooving we illustrate here. The first (Fig. 1, one-half actual size, as are all the illustrations of this

FIG. 1.

article) is a core from a tube drill hole in granite; on this, in one part, a continuous spiral of the lines of cutting may be traced for a length of 3 ft., passing five times around the core; and though, owing to rocking of the drill, it cannot be traced from end to end, yet no shallowing or widening of the grooves, indicating wear of the cutting point, can be seen in the course of the continuous spiral. The second (Fig. 2) shows the lines on basalt produced by the successive strokes of the saw; their regularity, both in depth and in distance apart, shows unmistakably that they are due to successive strokes of the cutting point, and not to any accidental or irregular causes. On other pieces of granite, diorite, basalt, and limestone similar marks may be found. One piece of diorite shows grooves one one-hundredth inch deep, cut without any irregularity or starting of the tool; and a piece of drill hole in diorite shows seventeen equidistant grooves, probably equal to a cut 20 ft. in length, without any appreciable difference in the groove from one end to the other. The fragments of diorite bowls with incised inscriptions, which were picked up by Mr. Petrie at Gizeh, show also the use of a graving point far harder than quartz; since the hieroglyphs are made by a cut with jagged edges, and not either scraped or ground. These are of the earliest period, as they bear the names of Semaferu and Khufu the two oldest kings of whom any contemporary remains are known.

Considering these examples of work—the definite grooves

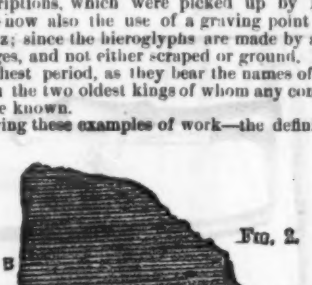


FIG. 2.

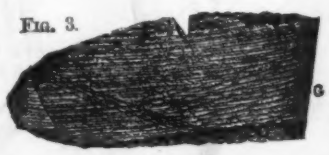
produced, their depth, continuity, and equality throughout, the capacity of the cutting point for dealing with the hardest materials, and the rapidity with which the cutting was done, the tube drills sinking one-tenth inch in granite at every revolution—it seems certain that no instrument but a metallic tool set with fixed jewel points could produce such results. The passage of the grooves without any interruption through the quartz, feldspar, hornblende, and mica of the red granite (as seen on the specimen in Fig. 1) is also a feature which shows brilliantly the capabilities of the tools, and the skill with which they were constructed. The strain on the cutting points in thus passing from a softer material into a patch of quartz would be enormous, far greater than if working continuously in quartz; and yet there is no starting, no burring, and no failure of the cutter.

If examples of work done by any grinding process be examined, it will be seen that there is not a trace of the definite grooves, such as are in the specimens alluded to. On modern lapidaries' work, done by a wheel fed with loose diamond powder, numerous shifts in the plane of the cut may be seen, showing the outline of the wheel; but no grooves or definite plowings in the material produced by individual points of diamond. Similarly in the tubular drillings done with soft iron and sand by the Chinese, or in similar work by other nations, there is never seen any trace of plowing out of the material; and, indeed, it seems physically impossible that any particle of a loose powder could become so embedded in a soft metal by the mere accident of rubbing that it could bear the immense strain needed to plow out a groove of considerable depth in such a hard material as quartz, or make a groove passing continuously through hard and soft material without any interruption or difference. This systematic use of jewel points set in some basis may, therefore, be considered as proved by the existing work, and the fact that the loose sand left in a cut and also the sides of some of the cuts are found to be stained green, leads to the conclusion that the metal of the setting was bronze.

What the jewels were is not yet known. The range of possible materials is limited to five minerals—beryl or emerald, topaz, chrysoberyl, sapphire, and diamond. Experiments made with beryl and sapphire show that their edges will fail under far less pressure than is necessary to produce cuts such as above described. Some amorphous stone is needed, and it is only the scarcity of diamonds which makes us refer to corundum as a likely agent.

The forms of the tools were just such as our modern experience has led us to use in the present generation. Long straight saws, circular disk saws, solid drills, tubular drills, hand gravers, and lathe tools were all made on the principle of jewel points set in a metallic base, while hammer and chisel, pick, and hammer dressing were also freely used where suitable. The straight saws were certainly as much as 8 ft. in length, as they cut a granite coffer 7 ft. 6 in. long from end to end. Their thickness varied from two-tenths in., as on large blocks of basalt, down to one-thirtieth in. on a small syenite trinket. The principal examples of sawing are the granite coffer of the Great Pyramid, on which the saw has been twice run too deep, and on each side of which the grooves of the saw may be seen; the granite coffer of the Second Pyramid, where the saw has been run too deep on the bottom, though the marks are polished out elsewhere; and a great pavement of basalt ⅓ acre in area, containing some thousands of blocks, all sawn into form and finely fitted together. This last adjoins the Great Pyramid, and is probably coeval with it. A fragment from it is shown in Fig. 2. A hand specimen of sawing in gray syenite, picked up at Memphis, is here illustrated (Fig. 3). It is

FIG. 3.



probably a piece of a statuary's waste, and is sawn on four sides, and has a crosscut also on the top

Of circular saws we have but one evidence as yet; this is a slice of diorite (Fig. 4), with the repeated circular sweeps

FIG. 4.

so familiar to our eyes on steam sawn timber. These must have been produced by the successive revolutions of the most prominent cutting point at the side of a disk edge set with jewels; and though the surface has been polished sufficient traces of the lines remain to show their character, and to prove by their exact equality, uniformity of cut, and regular spacing apart that they are not due to any casual or accidental cause. It has been suggested that the marks

might have been produced by a series of points set on a flat rotating face for planing down the flat bottom of a dish; but beside the fact that no flat-bottomed dishes are known, and that the polishing lines cross the surface in all directions, it would need greater skill to set a row of stones on a face so exactly to the same level as to make such marks than to set them on an edge for slicing. So the simplest explanation of the specimen is that a circular saw was used.

Though sawing was thus freely used for cutting the outsides of the great granite and basalt coffins, some other means was requisite for hollowing out the insides of such vessels. Here the inventive genius of the fourth dynasty exactly anticipated modern devices by adopting tubular drills, as the readiest and cleanest way of removing material with the least waste of force. These tubular drills varied much in diameter, thickness, and length. Those in softer materials, as alabaster, were smaller and thinner, not needing to carry set stones on the edge, but being merely worked with powder. But the larger ones, used for hollowing out granite on a large scale, were usually about 4 in. in diameter. One of the finest examples (about 2 in. in diameter) is in the pivot hole of a door in a lintel of the granite temple at Gizeh, built by the king of the Second Pyramid, Khafra. This is shown here (Fig. 5), drawn from a cast which Mr.

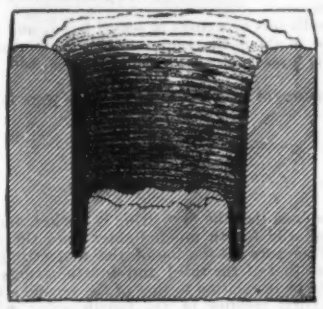


FIG. 5.

Petrie obtained by means of a gutta-percha mould. Here it will be seen that the core could not be broken out entirely, owing to its running into a tough patch of hornblende. The granite core already described (Fig. 1) is also a fine illustration of tubular drill work, and would be considered a creditable result by modern men using modern tools. The various examples of such drilling that have been found, mainly at Gizeh, may be tabulated thus:

Diameter.	Material.	
0·24	Alabaster.....	Tube 0·02 thick (Fig. 6); others up to.
0·7	"	Tube 0·04 thick.
1·8	Basalt	A hole in a vase.
1·9	Limestone....	A core.
2·2	Granite	Tube 0·1 thick (Fig. 5).
2·5	Alabaster.....	A core.
2·8	"	A core.
4·2	Granite.....	Inside of Great Pyramid coffer.
4·5	Greenstone ...	Fragment of waste.
4·8	Limestone	Two holes joined (Fig. 7).
4·8	Diorite.....	
18 0 (about)	Limestone ...	Rock dressing.

Of these the holes inside the Great Pyramid coffer show the length of drill used, as they end about 8 in. below the top. The holes in limestone show how closely they were placed together for hollowing out material; and the holes were all skillfully spaced so that each annular groove of the tool overlapped and used as much as possible of the cut next to it, so as to economize labor to the utmost. The rock

FIG. 6.

dressing at El Bersheh shows apparently the use of large tubular drills for clearing away masses of rock; the surface of a large excavated platform being covered with circular grooves, smooth around their bottoms as if produced by a continuous cut and not by chisel work, and just joining one another. This could not be the result of cutting out columns, as the rock surface is rough broken both within and outside of the smooth grooves, and the grooves sometimes intersect. This work is probably of the twelfth dynasty, or about 2000 B.C.; and hence later than the pyramid work, which is the principal subject of examination in the present inquiry.

Hence it seems almost certain that the tubular drill principle, of which examples are here described from ¼ in. to nearly 5 in. in diameter, was carried still further into sizes suitable for removing rock on a large scale; sizes which must have needed several men to turn the capstan head of the drill. Many other traces of the use of tubular drills were mentioned, as, for instance, in roughing out statues, but more particularly for beginning the hollowing of the insides of vases and bowls, which were afterward finished in the lathe.

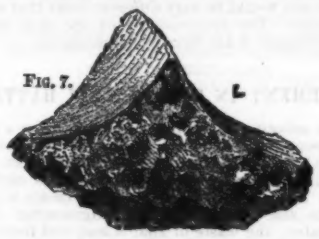


FIG. 7.

A peculiar feature of the cores and holes made by the tubular drills is a certain amount of tapering, which is always to be found. This tapering cannot have been produced by the mere rubbing of the side of the drill in turning round in the hole, since not only would such a cause be quite inadequate, but the grooves plowed out by the cutting points are just as distinct on the sides of the tube or core where it is tapered, as on the lower part. Hence it seems that not only did the Egyptians set cutting jewels round the edge of the drill tube, as in modern diamond crown drills, but they also set them in the sides of the tube, both inside and out. Thus the hole was continually rimered larger by the tool, and the core turned down smaller as the cutting proceeded, and so the tool could be withdrawn more readily from the groove, as the annular space was thus wider at the top than at the bottom. Other drills, not tubular, were used for very small holes, such as those in the symbolic eyes, which are drilled in syenite, 1·2 in. long, and only 0·08 in. in diameter.

Experiments made by the author seem to show that the minimum pressure upon a 4 in. drill could not be less than half a ton, and was probably two tons, and this is amply confirmed by the speed at which the tool is seen to have advanced, and is in accordance with the experience of modern engineers. Upon the granite core (Fig. 1) the grooves are a double spiral, showing that they were made by two stones at opposite sides of the tube; the pitch of the thread is one-tenth in., the circumference of the core about 7 in., and therefore the rate of sinking was one-seventieth of the distance traveled by the tool. The wonder is how any bronze tube or saw blade could bear the requisite pressure without doubling up, and how the jewels could be set in sockets to support them against such a violent drag.

Not only was a rotating tool employed, but the further idea of rotating the work and fixing the tool was also familiar to the earliest Egyptians. This is evidenced by the fragments of bowls turned in diorite. One piece of the bottom of a bowl (Fig. 8) shows the characterized marks of the

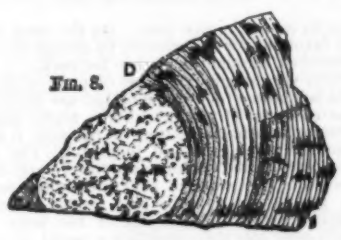


FIG. 8.

turning. Not only are there the circular grooves of the jewel-pointed tool, but also the marks of two different centerings, showing that the work had been displaced by the force applied in turning, and afterward reset, but not accurately, the old and the new surfaces meeting in a cusp. Other specimens of turning in black granite, basalt, and alabaster, all of the pyramid period, were exhibited by the author. The finest examples of turning in hard stone, however, are in the British Museum. Among these are a small, highly polished, narrow necked vase in diorite, or rather in transparent quartz with veins of hornblende, which has its neck only 0·05 in. thick, and a large vase of syenite turned inside and out, remarkably thin, considering the size of the component crystals. But the greatest triumph is a bowl of diorite (No. 4716), translucent and full of minute flaws, which must render it very brittle; yet this bowl, 6 in. in diameter, is only one-fortieth in. thick (0·024) over its greater part; just around the edge it is thicker, but a small piece broken out of the body of it shows its extraordinary thinness, no stouter than a thin card. An alabaster vase, of Unas of the fifth dynasty, almost rivals this in thinness, being only one twenty-fifth in. to one-thirtieth in. thick, but the softness of the material makes it of far less interest. A very favorite plan for narrow necked vessels was to turn them in two or three parts, and join these together, sometimes finishing off the inside on a fresh centering on the lathe. One example shows that the early Egyptians were familiar, not only with jeweled turning tools, but with mechanical tool rests, and with sweeping regular arcs in cutting. A fragment of a diorite bowl (Fig. 9) shows that the original

FIG. 9.

article was turned as a segment of a sphere inside by a tool working from a fixed center in the axis of the lathe, with a radius of 3·94 in. Having cut this spherical curve, the center of play of the tool was shifted about 0·5 in. higher, and 0·7 in. out of the lathe axis, and a fresh arc on the bowl was struck from this center, thereby cutting out a fresh curve which left a raised lip round the edges. The proofs of this explanation of the process are found in the exact equality of the two curves—that of the bowl in general and that under the lip—in the fact of the principal surface exactly coinciding with the inner edge of the lip, in the fact of the circularity of the section of the curves, and in the cusp formed where they meet, an awkwardness which no hand turner would ever take the trouble to make, but which necessarily results from a sudden change in the center of the arc of the tool. All these details have been worked out by the author from very careful measurements of the fragment, using successive templates of slightly varying radius to measure the exact curvature, etc.

In addition to the tools we have already described, graving instruments were employed in the production of intricate forms. Blocks of stones were likewise hammer dressed; sometimes saw nicks were cut ½ in. deep round a block, and then the hammer dresser was left to work the surface down to the plane of the grooves. Also on sawn blocks the surface to be placed in contact was usually hammer dressed to have sufficient space to hold the cement, while the edges were left quite smooth. For dressing surfaces to a true level the regular custom of the workmen was to use a trial or face plate, prepared as a true plane and smeared with red ocher; wherever the ocher came off on the stone they knew there was an excess, and accordingly dressed it off. The tool used appears to have been a sort of small adze, by which the stone was sliced down very delicately and regularly by hand. All the blocks of the Great Pyramid casing were prepared with these facing plates, as may be seen by the remaining touches of ocher on the prominent points. Not only on building stones, but also on rock dressing, the same ochering is visible. Where the stone was much larger than the facing plate, as was the block of granite over the king's chamber doorway, about 8 ft. by 12 ft., then a diagonal draught was cut along the stone from corner to corner, and thus any wind in the plane of the face was avoided. In a painting at Thebes the workmen are apparently shown chiseling down a stone to a plane face; they have a string stretched quite clear of the stone over an offset block at each side, and are then applying an offset piece to the face of the stone to see whether the face is in excess. This is a skillful method of working, as the excess does not bulge out the string, and can be exactly measured at they proceed, while the string does not need to be removed, as the chisel can be used under it. Working on a vertical face the bellying of the string does not affect it.

This completes the list of Egyptian tools dealt with by Mr. Petrie, but he adds many interesting details of the methods of building and quarrying, which, however, we can hardly notice as fully as the tools, since they do not present so great a novelty. The center lines of passages and stone blocks were carefully marked in red to guide workmen, and reference marks were added in case the first grew illegible or were covered up. In the rough courses of the mass of masonry of the pyramids the irregularities of the stones of one course were let into the course below them; thus each course bears on it a sort of plan, sunk to different levels, showing the stones that came above it. The method of fine dressing all the limestone was by carefully picking, as if with a small adze, and the standard of flatness appears to have been that no more than a couple of inches across should miss touching the true plane within the thickness of the smear of ocher. The method of quarrying the limestone was by driving galleries into the hillside and taking out a stratum of stone, leaving the hill standing above on the support of pillars. The manner of raising the blocks is not known except by inference, and that points to rocking them, and packing them up on two piles of timber near the center; but this does not afford a satisfactory explanation of the way in which some of the stones were got into place. For instance, the lower granite portcullis of the Second Pyramid, a block that would need forty to sixty men to lift it, was slid on its edge along a passage only 3½ ft. wide, and then slewed round in a complex way to turn it up into the grooves prepared in the rock for it to slide in. Not more than four men could well work at it, and these in a cramped space; hence some great advantage of leverage skillfully applied must have been available.

These investigations of the mechanical methods employed by the pyramid builders are but a small portion of the researches carried on by Mr. Petrie during two winters' residence in a tomb at Gizeh. The main object of this work was the accurate surveying of the pyramids with instruments of first-class precision, the results being obtained to within one or two tenths of an inch over ground half a mile across, by means of an extensive and closely checked triangulation. We hear that the Royal Society have recognized the value of the work, by giving a grant for its publication from the Government Grant for Research; and we may soon expect to have a full account of the instruments employed, the measurements obtained, and the bearing of these on the various theories of the pyramids, beside various historical and architectural notes, and a discussion of new methods in the mathematical treatment of observations.—*Engineering.*

ON THE FUNCTION OF THE SOUND-POST, AND ON THE PROPORTIONAL THICKNESS OF THE STRINGS OF THE VIOLIN.*

By WILLIAM HUGGINS.

SIR JOHN HERSCHEL says: "It (the bridge) sets the wood of the upper face in a state of regular vibration, and this is communicated to the back through a peg set up in the middle of the fiddle and through its sides, called the 'soul' of the fiddle, or its sounding-post."†

Savart says: "L'ame a pour usage de transmettre au fond les vibrations de la table . . . son diamètre est déterminé par la qualité du son qu'on veut avoir; il est maigre quand elle est trop mince, et sourd quand elle est trop grosse."‡

Daguin, in his "Traité de Physique," devotes a whole page to the discussion of the functions of the sound-post. The most important sentences are the following: " . . . L'ame n'agit pas comme conducteur du son. . . . Il nous semble que l'on doit expliquer l'effet de l'ame de la manière qui suit. L'ame, ou les pressions extérieures par lesquelles on la remplace, a pour effet de donner au pied du chevalet un point d'appui autour duquel il vibre en battant sur la table de son autre pied. Si l'un des pieds n'était appuyé sur un point fixe, il se releverait pendant que l'autre s'abaisserait, parceque les cordes n'agissent pas normalement à la table, puisque l'archet les ébranle tres obliquement, ce qui entraine le chevalet dans un mouvement transversal quand il n'a pas de point d'appui fixe. Lorsque l'archet est dirige normalement aux tables, cet inconvénient n'existe plus, et l'ame n'est plus nécessaire."§

Helmholtz says: "The vibrating strings of the violin, in the first place, agitate the bridge over which they are stretched. This stands on two feet over the most mobile part of the belly between the two 'f' holes. One foot of the bridge rests upon a comparatively firm support, namely, the sound-post, which is a solid rod inserted between the two plates, back and belly, of the instrument. It is only the other leg which agitates the elastic wooden plates, and through them the included mass of air."‖

The experiments¶ which follow have been made for the purpose of ascertaining whether it be any part of the function of the sound-post to convey vibrations to the back, or whether this post acts solely as a prop supporting the belly, so that its elasticity is not injured by the pressure from the strings, and also, as Daguin states, affords the firm basis which he considers necessary for one foot of the bridge.

* Paper read at the Royal Society, May 24, by William Huggins, D.C.L., LL.D., F.R.S.

† "Encyclopædia Metropolitana," article "Sound," p. 804.

‡ "Mémoire sur la Construction des Instruments à Cordes et à Archet," 8vo, Paris, 1819. Also Biot's "Report," *Ann. de Chimie*, tome xli., pp. 225-255.

§ "Traité de Physique, Acoustique," tome i, p. 375.

‖ "Sensations of Tone," translated by Ellis, p. 137. In the fourth German edition this passage remains unaltered.

¶ I wish to express my indebtedness to Mr. A. J. Ellis for some suggestions in connection with these experiments.

Mr. Hill and other practical men maintain that the quality of the wood of which the sound-post is made affects the tone of the violin, as undoubtedly do very minute differences of position. If the quality of the wood is important, we must admit that vibrations are conveyed by the post.

Whether or not the sound-post exercises the function of transmitting vibrations, it is obvious (1) that it performs the important duty of contributing to the support of the belly; (2) that the nodal arrangement of the belly and also that of the back are influenced by the pressure of the ends of the post against the upper and lower plates; (3) that Helmholtz is right, at least so far that the leg of the bridge under the fourth or G string has much more power than the other in setting the belly into vibration.

The usual way of investigating vibrations by the scattering of sand over the surface of the agitated body is difficult of application to the violin, on account of the curved form of the upper and lower plates. I found a convenient method to be by the use of what I may call a touch-rod. It consists of a small round stick of straight-grained deal a few inches long; the forefinger is placed on one end, and the other end is put lightly in contact with the vibrating surface. The finger soon becomes very sensitive to small differences of agitation transmitted by the rod.

The experiments were made on a strongly made modern violin, and in some cases repeated on a fine violin by Stradivarius in the possession of the writer.

The sand method, and also the touch-rod, showed that the position of maximum vibration of the belly is close to the foot of the bridge under the fourth string. The place of least vibration is exactly over the top of the sound-post behind the other foot of the bridge. The back is strongly agitated, the vibrations being least powerfully felt where the sound-post rests, which is nearly the thickest part of the back. These effects were very satisfactorily observed on a violoncello, where the phenomena are on a larger scale.

When the sound-post was removed from the violin, the large difference of the amount of vibration on the two sides of the belly was no longer present, the belly was about equally strongly agitated on both sides, making allowance for the string, which was bowed. The tone became very poor and thin, as is well known to be the case when the sound-post is removed. The vibration of the back was now very feeble as compared with its vibration when the sound-post was present, a circumstance in favor of the view that the sound-post conveys vibrations to the back.

A clamp of wood was prepared which could be so placed on the violin as to connect by an arch of wood outside the violin the place of the belly behind the bridge where the top of the sound-post presses with the place of the back where it rests. It was expected that the wooden arch would restore to some extent the connection of belly and back which was broken by the removal of the post, and carry, though imperfectly, vibrations from the upper plate to the back.

When this clamp was put on, the poor and thin sound was altered to the fuller character of tone which belongs to the violin when the sound-post is in its place. On testing the condition of the back, its normal state of vibration was found to be in a large degree restored If, while the strings were being bowed, the clamp was suddenly removed, the tone at the same moment fell to its poor character, and the vibration of the back as instantly diminished.

It was further observed that, if the upper part of the clamp pressed upon the belly without the lower part coming into contact with the back, the tone is altered in the direction as when the sound-post was present, but it was not until the lower part of the clamp was in contact with the back that the normal character of the tone was fully restored. A similar effect to that resulting from the pressing of one end of the clamp only was produced by firmly placing one end of a wooden rod at this part of the belly. This effect may be due to the setting-up in the belly, by pressure at this part, of the peculiar nodal arrangement which the post produces when in its place.*

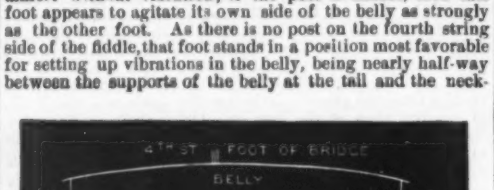
There could be no doubt that vibrations were carried by the clamp, for the lower end was powerfully agitated when the upper end rested upon the belly. If the sole function of the sound-post is to serve as a firm prop for the foot of the bridge, it should fulfill this condition most fully when placed under the foot of the bridge. In this position of the sound-post, however, as is well known, the tone is much injured

In order to separate that part of the function of the sound-post which serves as a support from the further function it may possess as a transmitter of vibrations, it was desirable to introduce such alterations in the structure of the sound-post as would enable it to retain its supporting power, and yet greatly modify and, if possible, stop its power of transmitting vibrations. A sound-post was made in which about half an inch of the middle was cut out, and a piece of lead inserted, also a sound-post in which instead of lead sealing-wax was put in. The effect of these compound posts, which retained uninjured their prop power, was to modify greatly the quality of the tone, but not to diminish its quantity in any marked degree, a result in favor of the view that the character of the wood of which the post is made does influence the tone, and that vibration is transmitted by the post. As these compound posts could transmit vibrations freely, it was desirable to contrive a post which would not carry vibrations and yet form a firm prop. A post was made with a piece of hard India-rubber inserted in the middle, but this post was found by experiment with a tuning-fork to transmit vibrations to some extent. Other materials were tried without success. A post capped at each end with pieces of sheet vulcanized rubber stopped almost completely the sound of a tuning-fork when the foot of the fork rested on the rubber over one end of the post, while the other end equally protected with rubber rested on a body capable of re-enforcing the sound of the fork. This rubber-capped post was firmly fixed in position in the violin, so that it would be able to support fairly well the belly and foot of the bridge, and yet not be able to carry vibration; unfortunately, it does not seem possible, from the nature of things, to have a *rigid* prop which does not transmit vibrations, but this post, with thin sheet rubber at the ends firmly forced into position, must have been fairly efficient in its supporting power. The effect on the tone was about the same as when the sound-post was removed. When the wooden clamp was put on, then the normal tone returned, and the back vibrated strongly.

These experiments appear to show that the sound-post is more than a prop, and that, besides its other functions, it does transmit vibrations to the back in addition to those which are conveyed through the sides.

* According to Daguin, some similar experiments were made by Savart, but I have failed to find them in those of his papers to which I have had access. "On peut la (l'âme) mettre en dehors, en l'appuyant à une espèce d'arcade dont on colle les pieds de chaque côté du violin. . . . On peut la remplacer par la pression d'un poids convenable appuyé sur la table supérieure." "Savart a conclu de là que l'âme a pour effet de rendre normales les vibrations de la table. . . ."—"Traité de Physique," tome i., p. 515.

Experiments with sand and the touch-rod appear to me to show that Helmholtz's statement is too absolute when he says "it is only the other leg of the bridge which agitates the elastic wooden plates." Undoubtedly it is the fourth string foot of the bridge which is the more powerful in agitating the upper plate; but the upper foot appears to me also to have an influence. When the post is placed exactly under the foot of the bridge, then the belly on this side is almost without vibration; if the post is absent, then this foot appears to agitate its own side of the belly as strongly as the other foot. As there is no post on the fourth string side of the fiddle, that foot stands in a position most favorable for setting up vibrations in the belly, being nearly half-way between the supports of the belly at the tail and the neck-



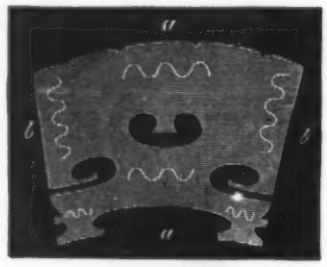
end of the violin. The other side of the belly, on the first or E string side, where the other foot of the bridge rests, is divided into two parts by the damping effect of the end of the sound-post—namely, the part, *a*, and the part, *b*. It is obvious that this foot of the bridge is unfavorably placed for setting the part of the belly, *b*, into vibration, since it is

so far from its central mobile part. On the other hand, its position is favorable for a portion of its energy of vibration to be transmitted through the post to the back.

Practically, very small differences of position of the top of the post behind the foot of the bridge are found to alter largely the character of the tone of the fiddle, and in the case of fine instruments the setting of the post is an operation demanding much care and judgment. The explanation lies probably in the circumstance that a small difference in the position of the post will alter greatly the proportion of energy passing through the post to that which is absorbed into vibrations of this side of the belly. At the same time it must also alter slightly the nodal arrangement of the belly, which must have an influence on the tone. If from the form of construction, or relative quality of the wood of the upper plate as compared with the under plate, the conditions of a violin are such that the highest quality of tone of which it is capable requires a relatively larger amplitude of vibration of the back, the position of the sound-post should be nearer the bridge. In a contrary condition of things the sound-post should be farther from the bridge. The extreme range needed in different violins is about a quarter of an inch. Any shift of the post must affect the relative mobility of the two sides of the belly.

If the sound-post transmits vibrations these will be in addition to those received from the sides of the violin. It may be, therefore, that one condition which determines the best position of the post is the degree in which from their form and material these fulfill this duty. All the sides must share in this duty, but the touch-rod shows that a large part of this action is borne by the parts of the sides which curve inward under where the strings are bowed. It is in harmony with this view that Mr Hill states that if the inside blocks at the corners, which are put to strengthen these parts, extend in a small degree into these curved portions, the tone is injured.

The plane of the vibrations of the strings is that in which they are bowed, which is more or less oblique to the bridge The vibrations may be considered divided into two sets at right angles to each other, *a* and *b*.



The touch-rod shows that these vibrations exist strongly in the upper part of the bridge. I venture to suggest that the use of the peculiar cutting of the bridge, which was finally fixed from trials, by Stradivarius, is to sift the vibrations communicated by the strings, and to allow those only or mainly to pass to the feet which would be efficient in setting the body of the instrument into vibration, the other vibrations which would be injurious in tending to give a transverse rocking motion to the bridge being for the most part absorbed by the greater elasticity given to the upper part of the bridge by the cutting. Below the two large lateral cuts, the touch-rod shows a very great falling off of the vibrations, *b*. In the case of a violoncello, these vibrations were also very greatly reduced below the side openings of the bridge.

The violin on which the experiments were made was without a bass bar, which is a piece of pine glued to the under side of the belly on the fourth string side. This bar is regarded as strengthening the belly, and also enabling it to respond better to the lower notes. The touch-rod showed no difference in the general behavior of this violin from a fine one by Stradivarius containing a bass bar.*

* In the "Early History of the Violin Family," Engel, speaking of the Crwth, says: "Furthermore, the contrivance of placing one foot of the bridge through the sound-hole, in order to cause the pressure of the strings to be resisted by the back of the instrument, instead of by the belly, is not so extraordinary and peculiar to the Crwth as most writers on Welsh music maintain. It may be seen on certain Oriental instruments of the fiddle kind which are not provided with a sound-post. For instance, the bridge is thus placed on the three-stringed fiddle of the modern Greek, which is only a variety of the ordinary rabáb, but which the Greeks call lyra. Inappropriate as the latter designation may appear, it is suggestive, inasmuch as it points to the ancient lyra as the progenitor of the fiddle."—P. 28.

On the Proportional Thickness of the Strings.—As the lengths of the strings are the same, we have only the two conditions of weight and tension, on which their pitch depends. It is obvious that for equal pressure on the feet of the bridge, as well as for more convenient fingering and bowing, the strings should be at the same tension. They should therefore differ in weight, so as to give fifths when brought to the same tension. The weights of the strings are inversely as the squares of the number of vibrations, which in the case of fifths is as 8 to 2, namely, as 9 to 4. As the first three strings are of the same material, it is more convenient to take their diameters, which must be as 3 to 2, that is, each string in advancing from the first string must be half as thick again as the string next to it. In the case of the fourth string, covered with wire, we must find the weight of the third string of gut, and take a fourth string of which the weight is 9 to 4 for the third string.

A good average thickness of 2d (A) string	=	0·0355 inch.
Then the strings should be: 1st	=	0·0237 "
2d	=	0·0355 "
3d	=	0·0532 "

A gut string 0·0532 inch in diameter weighs, when of the same length as a fourth string, 0·98 gramme, then the fourth = 2·20 grammes.

Ruffini sells sets of strings in sealed boxes, and these were found to be in about the same relative proportion to each other as the sizes indicated on the gauges sold by several makers.

The measures of a set of Ruffini's strings were found to be:

1st = 0·0265 inch.
2d = 0·0355 "
3d = 0·0460 "
4th = 1·4100 grammes.

It will be seen that the first string is thicker, and the third thinner, and the fourth much lighter than the theoretical values. Therefore the tension of the first string would be greater, and that of the third and fourth strings less than they should be in relation to that of the second string. The greater flexural rigidity of the fourth string will have a small effect in the direction of making the vibrations quicker, and therefore of making the tension required less.

By means of a mechanical contrivance I found the weights necessary to deflect the strings to the same amount when the violin was in tune. The results agreed with the tensions which the sizes of the strings showed they would require to give fifths.

A violin strung with strings of the theoretical size was very unsatisfactory in tone.

The explanation of this departure of the sizes of the strings which long experience has shown to be practically most suitable, from the values they should have from theory, lies probably in the circumstance that the height of the bridge is different for the different strings. It is obvious, where the bridge is high, there is a greater downward pressure. By this modification of the sizes of the strings there is not the greater pressure on the fourth string side of the bridge which would otherwise be the case. On the contrary, the pressure is less, which may assist the setting of the belly into vibration. There is also the circumstance that the strings which go over a high part of the bridge stand farther from the finger-board, and have therefore to be pressed through a greater distance, which would require more force than is required for the other strings, if the tension were not less.

SIEMENS' THEORY OF SOLAR ENERGY.

MR. ERNEST H. COOK, in the *Philosophical Magazine*, criticises Siemens' theory of solar energy. No evidence is found in planetary atmospheres of a difference in composition at high and low altitudes. Gay-Lussac and Thenard collected air in a balloon at an elevation of 7,000 meters and found that it contained exactly the same proportional quantity of oxygen as that collected at the same time in Paris. Brunner analyzed the air collected at the top and at the bottom of the Faulhorn and found the same proportions of oxygen and nitrogen Frankland has found that the composition of air up to altitudes of 14,000 feet is constant. There is, therefore, no terrestrial evidence of the separation of the constituents of the atmosphere, which the theory supposes.

Again, the evidence for the theory deduced from the composition of meteorites is not conclusive. In certain meteorites a very large proportion of carbon dioxide is found—much larger than exists in our atmosphere. This would seem to indicate that the meteor had passed through an atmosphere very rich in carbon dioxide. F. Mohr has shown that a large proportion of water is contained in the porous structure of meteorites, and he and Prof. Smith have also detected the presence of carbonaceous substances in meteoric bodies. When the meteor is raised to a high temperature by coming into contact with our atmosphere, the water of constitution would be decomposed, the hydrogen being set free and the oxygen would then combine to form magnetic oxide. The fused shell of the exterior of the meteorite would thus inclose gases at a high pressure. Since all the planets are also immersed in the supposed atmosphere of Dr. Siemens, an aerial current should form constantly in the northern hemisphere from the northeast, and in the southern from the southeast. These currents would be opposed to the "return trades" Mr. Cook discusses the dissociation effects in the atmosphere of the sun, and finds that the constitution of the gases projected into space would be very different from that supposed by Dr. Siemens. The spectroscopy of the stars moreover affords no evidence of Dr. Siemens' hypothesis.

IMPROVEMENT IN THE BUNSEN BATTERY.

M. AZAPIS substitutes for the acidulated water a solution of about 15 per cent. of cyanide of potassium, caustic potash, common salt, or sal ammoniac. The liquid in the porous vase which receives the carbon is common nitric acid, the same as in the Bunsen cell. The intensity is equal to Bunsen's; the zinc does not need amalgamating; the constancy is greater; the waste of zinc is less, and there is very little smell. A battery of 25 elements was used for four days without disturbing the mounting, and was employed every evening to produce electric light.—*Comptes Rendus.*

TUNNELING THE GREAT ST. BERNARD.—The preliminary surveys for this scheme are now being carried on with energy, and the engineers are of opinion that the gradients of the tunnel need not exceed from 23 to 28 in the thousand.

MASCART'S REGISTERING ELECTROMETER.

THE first model of this apparatus figured at the Universal Exhibition of 1878. In its construction, Mr. Redier applied the principle of the differential gear (which forms the base of his meteorological registering apparatus) to the registering of atmospheric electricity. The photographic processes then in use scarcely permitted of obtaining a continuous trace of variations so sudden as are frequently those of atmospheric electricity. The extreme sensitiveness of paper prepared with gelatino-bromide of silver, that science has availed itself of during recent years, has therefore led Mr. Mascart to modify his apparatus so as to utilize this marvelous property. Let us recall the fact, in the first place, that in studies of atmospheric electricity it is proposed to measure the potential of the air at a specific point, or rather the difference between the potential at such point and that of the surface of the ground, which is considered as null. As well known, on placing an insulated conductor (a metallic cylinder, for example) in the vicinity of an electrified body, it will itself become electrified by induction, and its two extremities will receive equal charges, and of contrary names. When such a cylinder is placed vertically in the atmosphere, the neutral line will be situated toward the middle, and its potential will be equal to that of the air at the height of such neutral line But it is almost impossible to insulate a conductor arranged in this way; so, in practice, the neutral line is carried artificially to one of the extremities of the conductor, and all the electricity therein is caused to flow out until the electric density is null at that point. Such a result is obtained by means of a flow of water arranged as will be explained further along.

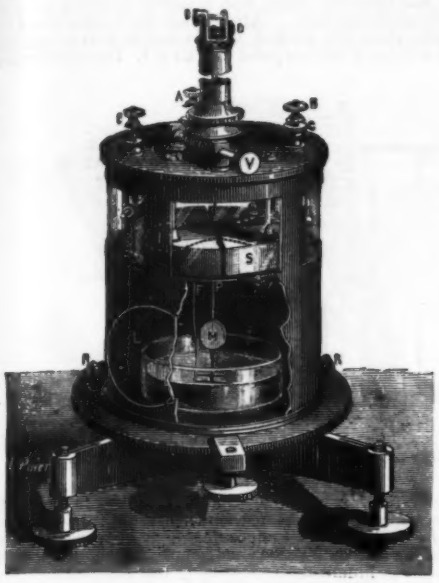


FIG. 1.—MASCART'S ELECTROMETER.

The new arrangement of Mascart's electrometer, as constructed by Mr. Carpentier, is shown in Fig. 1. An 8-shaped aluminum needle, I, is suspended horizontally by two cocoon threads in the interior of a sort of box formed of four hollow metallic sectors or quadrants, which are connected in pairs by copper wires. The two pairs of quadrants are insulated from one another and from the rest of the apparatus, and communicate with the exterior through two terminals, B and B', whose rod freely traverses an aperture in the metallic disk that covers the electrometer. Each terminal may be connected with the case, or insulated, at will, by raising or lowering a small ring, C. In the position, C the terminal and its corresponding pair of quadrants are insulated; but in C', on the contrary, these same pieces communicate with the case of the instrument, and consequently with earth.

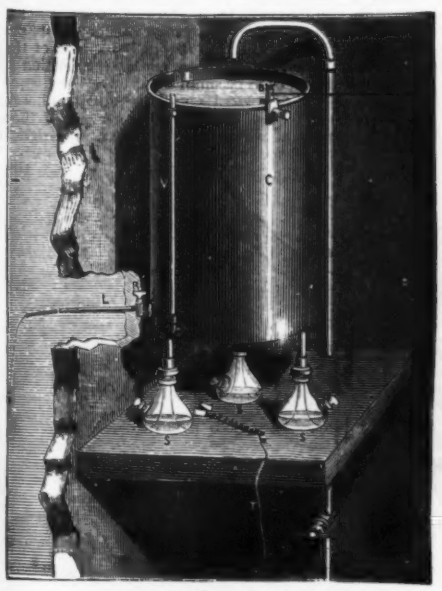


FIG 2.—COLLECTOR OF ATMOSPHERIC ELECTRICITY.

A platinum wire, P, fixed to the needle, carries a vertical plane mirror, M, and its extremity, which dips into a vessel containing concentrated sulphuric acid, is traversed by two rods fixed at right angles and designed for checking the oscillations of the needle. A second platinum rod, F, which dips likewise into the vessel of sulphuric acid, ends in the terminal, A, and is connected by a wire with an insulated reservoir filled with water. The entire apparatus is inclosed in a cylindrical metallic vessel containing, in front of the mirror, an opening in which is inserted a plano-convex lens, L. This case, which is constantly in communication with the ground, protects the needle against currents of air and prevents all external electrical influence. The metallic tube that surmounts the apparatus terminates in a roller, D, upon which is wound the extremity of the bifilar system. A screw, D', threaded in two directions, permits of modifying at will the distance apart of the two threads, so as to regulate the sensitiveness of the instrument. Finally, by means of a tangential screw, V, placed at the base of the tube, the needle, and consequently the mirror, is brought into a position proper for observation.

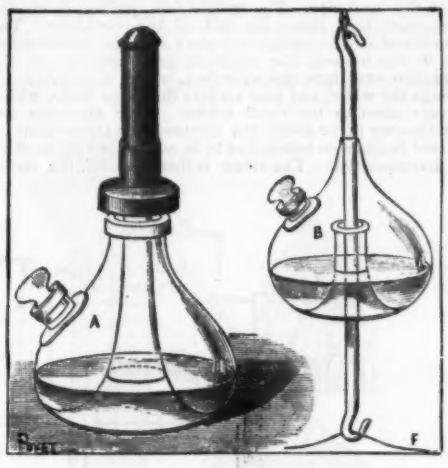


FIG. 3.—INSULATOR.

The collector of atmospheric electricity consists of a fine stream of water that escapes from a reservoir, C (Fig. 2), which possesses a capacity of about 50 liters, and which is filled twice a day, at intervals of 12 hours. The water flows out of doors continuously through the extremity of a tube, L, about 1 5 m. in length, which traverses the wall through an aperture made for the purpose.

The discharge, which is regulated by the cock, R', is such that the stream resolves itself into small drops at four or five centimeters from the orifice of the tube. The level of the water in the interior is shown at every instant by a communicating glass tube, V. The reservoir, which may, when need be, be put in communication with the earth, through the wire, T, is supported by insulating feet, S, which have a peculiar form, the device of Mr Mascart. The conducting wire, F, is likewise completely insulated by insulators constructed upon the same principle.

These insulators are represented in Fig. 3. One of them, A, is arranged for being placed upon a shelf or bracket, while the other, B, is designed to be hooked to or suspended from something. The insulator, A, consists of a sort of water bottle (*carafe*), the bottom of which is prolonged internally and terminates in a rod which issues through the neck, and which is covered with a metallic tube upon which runs a slide provided with a cap that is capable of almost completely closing the aperture of the flask. In the insulator, B, the bottom of the carafe projects internally to form an open tube through which passes a glass rod terminating in hooks. Each insulator contains concentrated sulphuric acid. In both cases the central rod is protected against dampness by the acid, and constitutes a perfect insulator.

When the electrometer is to serve only for laboratory experiments, the operator may confine himself to reading the deviations of the mirror, M, by means of a telescope and graduated scale, precisely as is done with direct reading apparatus showing magnetic variations. But the potential of the air is an essentially variable quantity, as shown by the curve in Fig. 5, and, in order to obtain an idea of the phenomenon, it would prove illusory to content one's self with taking its points at fixed epochs. A registering apparatus must, then, form a complement to the electrometer.

The present method of registering is exactly the same as that used with magnetic apparatus, and is briefly as follows.

A clock case, H (Fig. 4), is divided vertically into two separate parts by a wooden partition, one of these parts containing a clockwork movement, and the other forming a dark chamber which contains a frame that descends throughout its entire length in twenty-four hours, and carries with it a sheet of paper sensitized with gelatino-bromide of silver. A lantern, L, contains a small gasogen lamp, which transmits to the electrometer luminous rays that are reflected from the lens and from the mirror fixed to the needle

We will suppose that concentrated sulphuric acid has been poured into all the insulators (that have previously been washed and dried), as well as into the vessel into which the platinum wires dip. The relative height of the clock and electrometer is regulated in such a way that the rays emanating from the lamp fall, after reflection, exactly upon the slip behind which the photographic frame slides. These rays form two images upon the sensitized paper, one of which, due to reflection from the plane surface of the lens, has a fixed position and traces a slight line, while the other, due to reflection from the mirror, follows all the movements of the needle and traces a varying curve.

To arrange the apparatus for experiment, we begin by putting the electrometer case in communication with the earth by means of a wire, T (Fig. 2); and then connect the two pairs of quadrants, through the terminals, B and B' (from which the rings, C and C', have been removed), with the two poles of a pile, P, of 20 Volta elements, the central one of which should communicate with the ground in order that the apparatus may preserve a perfect electric symmetry. The two pairs of quadrants are thus at equal potentials and of contrary signs; and the needle kept in communication with the earth, takes a certain position of equilibrium. By means of the tangential screw, V (Fig. 1), the bifilar suspension is revolved until the movable image becomes confused with the fixed one. The position of zero, which corresponds to a null potential, being thus determined, the terminal, A, is united to the wire, F, which terminates in the insulated reservoir, and the ring fitted to the terminal is raised.

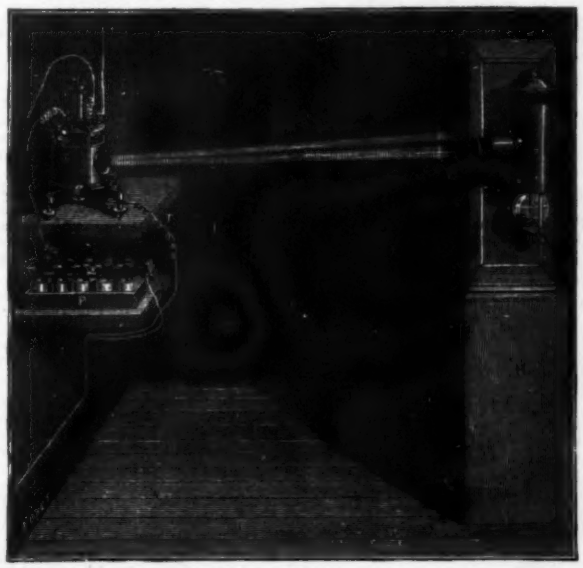


FIG 4.—METHOD OF REGISTERING IN CONNECTION WITH MASCART'S ELECTROMETER.

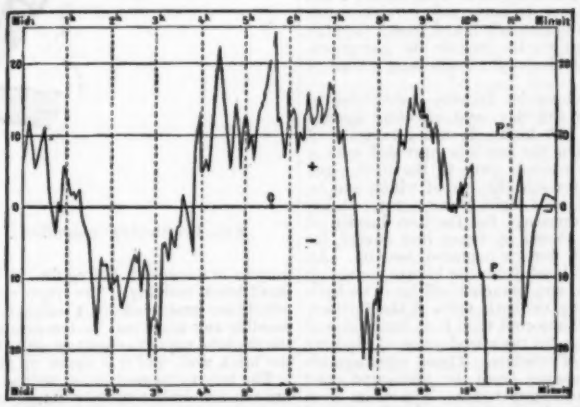


FIG. 5.—SPECIMEN OF CURVES GIVEN BY MASCART'S REGISTERING ELECTROMETER (Slightly Reduced).

The insulation of the different parts is verified by special experiments. If such insulation is perfect—and it is indispensable that it shall be—the movable image will at once be seen to deviate in one direction or the other, according to the nature of the atmospheric electricity; and the angle of the deviation, when comprised between certain limits, will be proportional to the potential of the air at the point where the flow occurs. It remains now to graduate the instrument, that is to say, to measure in known units the value of the curve's ordinate. To do this, we remove the wire, F, and connect the terminal, A, of the electrometer with the positive pole of a Daniell pile (of ten elements, for example), the other pole of which communicates with the earth. The movable image deviates and stops after a few moments at a certain position, P (Fig. 5). The apparatus is left in this state for from six to ten minutes, the length of time necessary for the paper to take an impression, then the poles of the auxiliary pile are changed around. We thus obtain a second image which is symmetrical with the first, and which leaves a trace at P' on the sheet. The half distance, P P', measures the deviation produced by the ten Daniell elements. We can thus express exactly, in Daniell elements, the potential of the air at any instant whatever. When the reservoir is put in communication with the earth, when, for example, it is filled with water, the movable image returns at once to zero and leaves upon the paper a trace, O, which lasts until the insulation has been established again. The registering apparatus thus gives, of itself, a daily variation of the zero. The graduations should be renewed frequently, for, in fact, the first conditions of insulation do not last indefinitely; the acid becomes hydrated, and, degree by degree, the deviations with the same charge diminish in amplitude. When the waste becomes very evident, the apparatus must be taken apart, the reservoir be taken down, and the renewing of the sulphuric acid in the insulators and vessel of the electrometer must be proceeded with with all the precaution derived from experience.

The practical details connected with changing the paper in the photographic frame, and with removing and fixing the proofs, are absolutely the same as those described in connection with the registering magnetometer, and we need not repeat them.

Mascart's electrometer, applied to the registering of atmospheric electricity, was installed in the first place in the physical laboratory of the College of France, and is now in regular operation in the meteorological observatories of Saint Maur Park, Nantes, and Perpignan, and at the Lyons Observatory, etc. Before long, other establishments are to put it on trial.

As yet, the causes and place of origin of the electric actions of which the atmosphere is the seat are unknown. Several physicists, it is true, have, from their own observations, obtained important results, but the phenomena in general can only be studied with advantage by a discussion and comparison of continuous observations made simultaneously at a large number of points. The apparatus that we have just described furnishes a simple and convenient means of collecting data for such an object.—*La Nature.*

WATER GAS IN AMERICA, AND HOW IT IS MADE.

By Albert P Hallock, Ph. D., Chemist to the New York Gaslight Company.

There have recently been published some articles on the subject of the "Manufacture of Water Gas in America." As this gas is extensively used here, I thought your readers might be interested in a description of the method of its manufacture, according to the "Tessié du Motay" process as now practiced by some of the oldest and largest gas companies in New York and other important cities.

Water gas for illuminating purposes is made by decomposing steam by means of incandescent carbon, enriching the resulting gases with naphtha vapor, which is rendered permanent by passing the mixture through red-hot retorts. The gas is then purified in the same manner as coal gas.

The necessary apparatus is shown in outline in the accompanying engraving, with the exception of the parts required for purification, which have been omitted, as they in no way differ from those used in the purification of coal gas. The apparatus consists of—

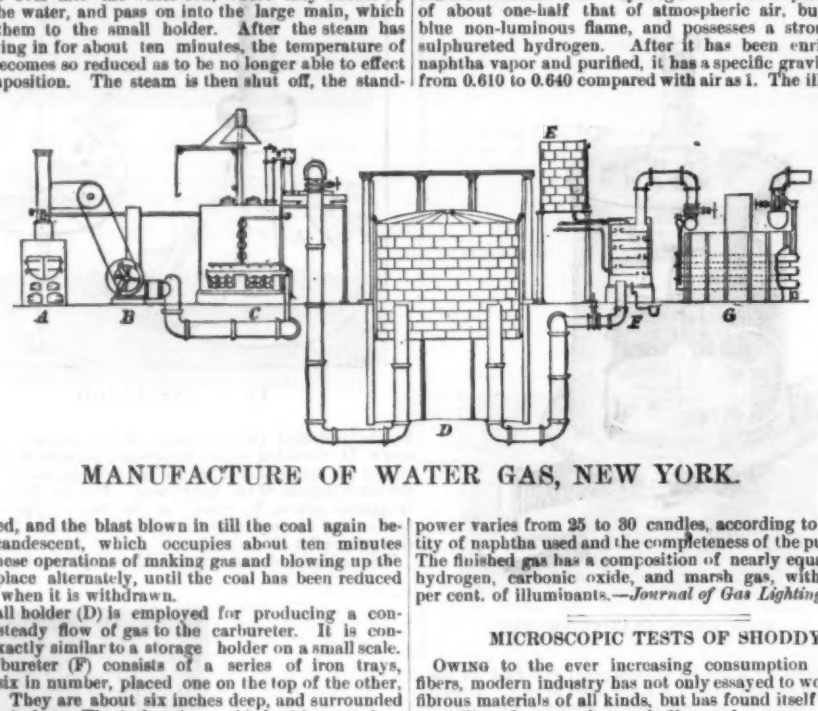
A, Boiler for generating steam.
B, Blower for furnishing a blast of air.
C, Gasogene for decomposing the steam.
D, Small gasholder acting as a governor.
E, Tank for holding naphtha.
F, Carbureter for enriching the gas with naphtha.
G, Retorts for fixing the naphtha vapor.

The number of pieces of each apparatus required will depend entirely on the quantity of gas intended to be manufactured.

The first two pieces of apparatus do not need special description. The first one, A, is simply an ordinary horizontal tubular steam boiler, built up in a brick furnace, and provided with a pressure gauge, injector, safety-valve, steam dome, etc. In it the steam is generated, and passes through the horizontal pipe (shown on the top) to the gasogenes. The next piece, B, is an air blower for furnishing a blast of air to the gasogene.

The gasogene, C, is a rectangular furnace constructed of wrought iron, lined with fire-clay, and standing upon a brick foundation some 2 feet high. It has a capacity of about 10 tons of coal. On the top it is provided with a stand-pipe, which not only extends over to the main pipe, but has a short vertical extension, the end of which can be opened or closed by means of a tight-fitting cover. It has also on the top two large openings for the introduction of coal. These openings are closed by heavy iron covers, for the lifting of which a small derrick is placed near by. An air-pipe conducting the air blast from the blower comes up at one end of the gasogene, and branches off into two horizontal arms which run along on both sides of the furnace. Just below this pipe, and connected with it on both sides of the furnace, are six openings for the introduction of kindling as well as the removal of cinders. These openings are closed by iron doors. Branches from the blast-pipe enter just behind these doors on the upper side. The steam from the boiler comes through the horizontal pipe by the side of the gasogene, and passes through a series of horizontal superheaters set in the fire-brick partition wall of the furnace. From the superheaters it passes through the horizontal pipe running along just above and parallel to the blast-pipe, entering the furnace by the six tuyeres over the door.

The working is as follows: The covers are lifted from the openings on the top, the cover is removed from the stand-pipe, and the doors on the sides are opened. A quantity of wood is then introduced into the furnace and lighted. As soon as the wood becomes well ignited, some anthracite coal is introduced, and the doors are closed and luted. Coal is added until eight or ten tons have been put in, the covers are replaced on the top, the valve on the top of the vertical blast-pipe at the end opened, and the blast permitted to blow into the mass of coal. When the workman (judging from the flame issuing from the stand-pipe) sees that the mass of coal has become incandescent, he lowers, by means of the handle, the valve on the blast-pipe, shutting off the blast. He then opens the steam-valve, and permits the superheated steam to enter; he also unhooks the long rod which holds up the weight attached to the cover at the top of the stand-pipe. The weight falls, pulling down the cover, and thus closes the end of the stand-pipe. The superheated steam coming in contact with the incandescent coal is decomposed, the resulting gases passing up the stand-pipe over into the water-box, where they bubble up through the water, and pass on into the large main, which conveys them to the small holder. After the steam has been blowing in for about ten minutes, the temperature of the coal becomes so reduced as to be no longer able to effect the decomposition. The steam is then shut off, the stand-pipe opened, and the blast blown in till the coal again becomes incandescent, which occupies about ten minutes more. These operations of making gas and blowing up the coal take place alternately, until the coal has been reduced to cinder, when it is withdrawn.



MANUFACTURE OF WATER GAS, NEW YORK.

The small holder (D) is employed for producing a constant and steady flow of gas to the carbureter. It is constructed exactly similar to a storage holder on a small scale.

The carbureter (F) consists of a series of iron trays, generally six in number, placed one on the top of the other, gas-tight. They are about six inches deep, and surrounded by a steam-jacket. The jacket is provided with two pipes—one connected at the top for the steam to enter, and the other near the bottom to carry off the water resulting from the condensation of the steam.

A sheet-iron tank (E) holds a supply of naphtha, and has a pipe leading to the top tray. This pipe is provided with a valve for regulating the supply of naphtha. The trays have rectangular openings in the bottom, which permit the gas to pass up from one tray to the next, and they are so arranged that the openings will not be directly over each other, but one at either end, to compel the gas to pass the whole length of one tray before entering the next. Around each of these openings is a rim about three inches high to prevent the naphtha from running over into the next lower tray until it attains that depth. The gas enters at the bottom, passes up through the openings backward and forward over the trays, and out by the pipe at the top. A slow stream of naphtha (about five gallons to every 1,000 cubic feet of gas) is allowed to run into the top tray. When this becomes full to the top of the rim, the naphtha overflows into the next tray, which in turn overflows into the next, and so on; but it seldom reaches the two lower ones, being all volatilized before it can do so. The heat of the steam in the jacket causing the naphtha to vaporize, the vapors unite with the gas and are carried along with it.

After leaving the carbureter the gas goes to the retorts, G; and in so doing should pass through as short a pipe as possible. In order to effect this, and yet not have the carbureter in danger of taking fire, it is generally placed in a small brick building. The pipe conveying the gas to the retorts is surrounded by a steam coil, to prevent as far as possible any reduction in temperature, which would cause the naphtha vapor to condense out. This pipe passes through the brick wall, and it is sealed up all round.

The retorts themselves, as well as the oven in which they are set, are similar to those employed in the manufacture of coal gas, with the exception that they are constructed to receive gas at one end and deliver it at the other. The gas coming from the carbureter enters a horizontal pipe running along on the top of the oven. Connected with this is an inlet-pipe coming down by the side of each row of retorts, in which there are generally three, one above the other, and a short pipe in which there is a valve connecting each one of the retorts with the pipe coming down the side. The gas enters the front end of the retort, passes the whole length of it up the stand-pipe through the hydraulic main, and on to the purifying apparatus (not shown). On the pipe leading to the hydraulic main is a small stopcock for testing the gas to see whether the naphtha vapor has been properly fixed. This is done by allowing the gas to impinge upon a piece of white paper. If the stain is too light, the heat in the retorts has been too low; if too dark, the reverse is the case. The workman then shuts off the gas from those that are too cool, and lets more into those that are too hot.

The impurities in water gas are of about the same class as those found in coal gas, with the exception of ammonia, which is seldom met with in water gas. The amount of sulphur in crude water gas made from a good quality of anthracite coal is only about one-third that contained in crude coal gas. The gas as it comes from the gasogene is properly the water gas; but, for convenience, it is called by the manufacturers the "hydrogen." It has a specific gravity of about one-half that of atmospheric air, burns with a blue non-luminous flame, and possesses a strong odor of sulphureted hydrogen. After it has been enriched with naphtha vapor and purified, it has a specific gravity ranging from 0.610 to 0.640 compared with air as 1. The illuminating power varies from 25 to 30 candles, according to the quantity of naphtha used and the completeness of the purification. The finished gas has a composition of nearly equal parts of hydrogen, carbonic oxide, and marsh gas, with about 15 per cent. of illuminants.—*Journal of Gas Lighting.*

MICROSCOPIC TESTS OF SHODDY.

Owing to the ever increasing consumption of textile fibers, modern industry has not only essayed to work up new fibrous materials of all kinds, but has found itself compelled to utilize the manufactured fibers of worn out fabrics. Linen and cotton rags find important application in paper making; but those of silks and woolens cannot well be used for a like purpose. All intermixture of the last named with new wool or otherwise now constitutes an important article of manufacture under the name of shoddy (*laine regenerée*); and as in most cases the linen and cotton threads have not been removed, it often happens that a single yarn of shoddy will contain all four of the textile fibers just named. But shoddy, though difficult to distinguish from new wool by its looks, is inferior thereto in quality and strength. Hence the need of accurately defining its distinguishing characteristics, as much on account of the difference in price as to prevent frauds.

The chemical agents at our disposal, says Dr. R. Schlesinger, of Zurich, in a pamphlet relating to this subject, enable us to ascertain whether shoddy contains silk, cotton, or flax, besides wool, and even in the more favorable cases to determine approximately the proportion of each. Undoubtedly these results are in themselves of no small value, but they do not go far enough, inasmuch as when, after prolonged chemical experimentation, we arrive at the fact that a given sample of shoddy contains a certain proportion of wool, the knowledge is of very small avail unless we know also how much of it is new wool and how much old wool that has been used before. This is precisely one of those questions, the solution of which is of the utmost practical interest.

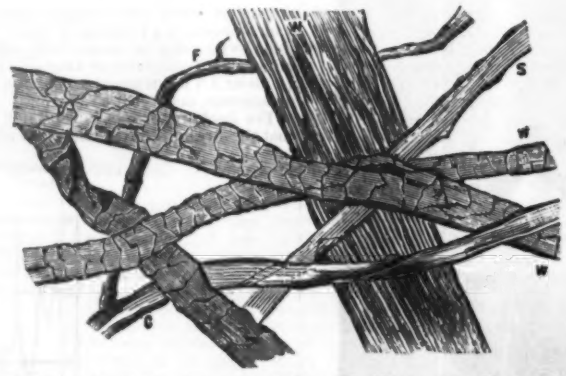


Fig. 1.—Shoddy (magnified). C. Cotton fibers. S. Silk. W. Wool. W'. Wool after treatment with acid.

But chemistry aids us not, as the substance of the wool undergoes no chemical change in the manufacture; the structure and appearance only are modified. The microscope alone can decide the question.* Our knowledge is yet insufficient to carry us very far, with certitude, in this the only road to the desired end. By and by this may be otherwise, but even now we know enough to obtain approximately exact results, which are themselves a very valuable acquisition. The examination of shoddy comprises two distinct processes: 1. The identification of the component fibers; 2. The quantitative analysis of the same. The former, or qualitative analysis, we will consider first.

When shoddy is observed with a magnifying power of 100

* A microscope capable of giving a clear, well-defined image, with a power of 350 diameters, should be used, although a lower power 30 to 50 diameters, will usually suffice to distinguish the fibers. The microscope should have a micrometer eyepiece, as the dimensions of the various fibers furnish useful methods of distinguishing them from each other. A few micro-chemical tests, as sulphuric acid, concentrated and dilute, iodine, cupric ammonia, etc., will be required.

to 150, there will usually be seen in it, intermingled with numerous scaly hairs of wool, W (Fig. 1), some smooth amorphous filaments of silk, S, and often thick-membraned cellular fibers of flax, F, or cotton fibers convoluted spirally on their axes, C. The colors of these fibers are generally various, so that microscopically the object presents a multi-colored image. Having thus satisfied ourselves by several independent experiments of the presence of different textile fibers, the next thing is to test the results by placing a drop of cupric ammonia on the object. This reagent will quickly destroy the silk and cotton, and will then begin to attack the flax, leaving the woolen fibers slightly swollen. If another sample be treated in the same manner with concentrated sulphuric acid, the wool will be dissolved, producing a red coloration. Having thus ascertained the several sorts of fibers contained in the sample of shoddy under consideration, we have next to subject one of them, the wool, to closer examination to determine whether it consists wholly or only partially of wool which has been used before. For this purpose it will be requisite in the first place to compare

FIG. 2.—Hairs of shoddy wool (magnified).

the colors, structure, and chemical characteristics of both kinds of wool.

The most striking difference is found in the color of the hairs. In most shoddies there will be found woolen fibers dyed and undyed, the latter being pure white, or bearing traces of the color they once had, which has been removed by bleaching. In better kinds the hairs are all of one color, and in inferior sorts they are generally of divers hues. In a single yarn of shoddy have been found woolen fibers dyed with indigo, with purpurine, and with madder. This in itself is proof sufficient that they have not been dyed together, but we owe their color to the dyeing of the several fabrics of which they once formed part. The fact is absolutely impossible to detect with the naked eye, as shoddy generally presents great uniformity of appearance externally, owing to the regular distribution of the fibers, and the predominance of some prevailing shade among them. Another important distinction between the two kinds of wool is the difference in their diameters.

The hairs of shoddy wool are never so uniform in structure or constant in diameter as those of new wool; they contract gradually or suddenly, expand again, again contract, or remain uniform in size throughout the rest of the length, and so on. In many places the scales are rubbed off; in others the hair is worn down so that at these parts the diameter is often below the average; indeed, it is not uncommon thus to find a diameter of 0·01 millimeter, or even less. The length of the wool, which can be observed with the naked eye, also affords a good distinguishing characteristic. Again, the behavior of each kind of wool in strong potash, or soda lye, or in sulphuric acid, may also be employed to distinguish them. Potash or soda lye attacks, and consequently distends, the hairs of shoddy wool much more speedily than those of new wool which have undergone no alteration.

Woolen hair treated with concentrated sulphuric acid swells more or less; its scales stand out more and more as the acid penetrates into the interior of the hair; its primitive structura disappears gradually, until the moment arrives when the internal band of light which it shows under the microscope disappears altogether, and there remains but an elongated cell covered with longitudinal striæ and fissures. Fig. 3 shows shoddy wool viewed in water with a magnifying power of 500 diameters. Fig. 3 shows the same wool after the action of sulphuric acid, and just as its original structure has vanished. With prolonged action of acid the hairs often split longitudinally, so that in the end they break up into fine separate threads. Hair of new wool (Fig. 4) behaves in a precisely similar way, only the time requisite for the acid to work the change described is usually much greater than is needed to destroy the primitive structure of shoddy wool. Experiments to determine this important characteristic of shoddy wool were made in the following manner: On the slide of the microscope were laid crosswise a hair of shoddy wool and a hair of new wool, which had been carded and consequently divested of the grease coating

FIG. 4.—Hairs of new wool, magnified 350 times. Lengths average, according to sort, from 4 to 32 cent. diameter, 0·014 to 0·06 millm.

it in its normal state. A drop of concentrated sulphuric acid, of 66° Baumé, was placed on the point of contact of the two hairs, and the respective times of its touching each hair noted; a slip of glass was then laid over it, and the object observed with a magnifying power of 65 diameters. This power is enough for the purpose, and has the additional advantage that the acid being at some distance from the object glass, the latter is preserved from injury. Things being thus arranged, it will be observed in every case that the hair of shoddy swells much more quickly and to a much greater extent than the hair of new wool, and that the former, if dyed, almost invariably loses its color, the discoloration gradually extending from the scales to the medullary canal, until the whole has assumed one uniform tint. This is, of course, coincident with the disappearance of the primitive structure, or at least follows immediately upon it, so that it facilitates the determination of the instant at which this structure is effaced. But in cases where there is no discoloration the moment may be fixed without difficulty, as the peculiar scale structure of the hair is only rendered more prominent by the preliminary action of the acid. As soon as the transformation is complete in one hair the time is noted, the coefficient so furnished indicating the relative resistance to the acid of the object under examination.

FIG. 3.—Wool in which the primitive structure has been destroyed by acid (magnified).

It is indispensable to observe that not more than a single hair of each kind of wool should be placed in the microscope at once, as the time needed for the sulphuric acid to destroy the structure of new wool varies greatly, depending as it does on the description of wool, the volume of acid, the strength of the capillary current, and the friction and degree of pressure exerted by the glass slips. Not further to aggravate these difficulties, it is well to let the acid reach the object by first depositing it, with the aid of a glass rod, at the edge of the slips, as usually is done in micro-chemical experiments.

To give a clearer idea of the results thus obtained, an example is subjoined of a series of experiments executed with hairs of shoddy of different colors and obtained from different sources:

Number of experiment.	Hair of shoddy changed from	Time occupied in destruction of primitive structure. Shoddy hair. m.	sec.	New wool hair. m.	sec.
1.	Green to yellow	3	45	4	05
2.	Brown to light brown	3	15	4	15
3.	Violet to colorless	3	15	2	55
4.	Black to red	2	10	4	00
5.	Red to light red	1	45	6	05
6.	Blue to colorless	1	45	1	25
7.	Yellow to dirty yellow	1	30	3	45
8.	Pink to yellow	1	15	2	20
9.	Black to yellow	1	05	5	10
10.	Deep green to gray	1	05	1	50
11.	Deep yellow to light yellow	1	00	1	45
12.	Deep brown to yellowish red	1	00	1	15
13.	Light gray to colorless	0	45	1	30
14.	Light gray to colorless	0	30	1	10
15.	Colorless to colorless	0	15	4	30

It appears from these experiments that the destruction of the primitive structure of woolen hair by the action of concentrated sulphuric acid takes place much more rapidly in most cases in shoddy than in new wool, and as the changes in color likewise afford a distinguishing characteristic, we have in this reagent a valuable test for wool.

We have next to consider the quantitative analysis of shoddy. This problem may be solved in two ways—by purely chemical tests and by the microscope. But as our methods of quantitative determination are very imperfect, we can here look for but very inexact results, which merely afford some idea of the approximate percentages of each kind of fiber in any sample of shoddy subjected to examination. To separate the wool and silk from the cotton and linen fibers by chemical means, it will be sufficient to boil the shoddy in strong potash or soda lye. The first two are dissolved in the reagent; the other two remain undissolved. To separate the wool from the silk, concentrated sulphuric acid is employed, which dissolves the silk in a very short time, leaving the wool intact. As soon as dissolution of the silk has taken place, the fluid should be largely diluted, otherwise the wool will likewise be attacked in turn.

The chief difficulty here experienced is in the separation of the swollen woolen fibers from the glutinous mass of dissolved silk. For this purpose a coarse filter is used having meshes large enough to allow of the percolation of a viscous fluid without permitting the woolen hairs to pass through. As, owing to their scales, these hairs readily cohere, a sort of felted mass is obtained which can be easily dried and weighed. It is well to make a check analysis, as the numerical results when thus confirmed acquire a considerably increased value.

Quantitative analysis of shoddy with the microscope can be thus effected:

Several microscopic preparations of the shoddy are made with the greatest care, particular attention being paid to making the fibers lie parallel, avoiding crossing and overlapping.* These are examined with a magnifying power of 20 to 50 diameters, which suffices for the identification of the various fibers; but the field of vision must be as ample as possible. The number of fibers of each sort is then counted, which gives us approximately not only the proportions in which they are intermixed, but likewise, if heed has been paid to it in counting, the number of woolen hairs in a single yarn of the shoddy.

Micro-chemistry now comes in with its potent aid, enabling us, as we have seen, to recognize and identify the shoddy fibers by the greater rapidity of their dissolutions in alkaline liquors, and the facility with which the original structures of the wool become effaced under the influence of sulphuric acid. These characteristics, it is true, are uncertain, and can only be distinguished by a practiced eye. Unfortunately, however, up to the present we possess no better means, although it is to be hoped that the progress of scientific research will bring the process of testing shoddy microscopically, like other processes, to a greater degree of perfection, or will provide some more efficient substitute—a result which in either case cannot fail to prove of inestimable value to manufacturing industry.—*Textile Manufacturer.*

BEECHWOOD CREOSOTE.

By H. HAGER.

PURE beechwood tar creosote is not soluble in double its volume of anhydrous glycerin, but forms therewith a milky-white or whitish mixture, which ought not to be colored. Other creosotes dissolve in double their volume of glycerin. To detect phenol, 3 vols. of a 75 per cent. creosote are mixed with one vol. of the suspected creosote and well shaken. On settling there are formed two strata, a turbid one below and a lighter layer. The latter consists of the creosote which has given up its proportion of phenol to the lower stratum, its volume becoming smaller according to its proportion of phenol. In order fully to remove the latter (at least up to 98 per cent.) from the creosote, the upper layer is again shaken up with three times its volume of 75 per cent. of glycerin as before. On shaking up with ammonia at 5 per cent. the phenol passes into the latter, while the beech-tar creosote remains undissolved. If the sample is mixed with an equal volume of soda-lye at sp. gr. 1·334, it should form a clear yellow permanent liquid, a slight degree of heat being liberated One vol. of beech-tar creosote dissolves completely and clearly in 2 vols. of petroleum benzine, and the solution should be almost colorless or yellowish. Creosote containing even 5 per cent. phenol or cresol gives a turbid mixture. The solution of the creosote in petroleum benzine is divided into three parts. The first is shaken up with an equal volume of liquid ammonia, the second with caustic soda-lye of sp. gr. 1·160. In neither should a dark coloration appear in the course of half an hour. The third portion is shaken up with an equal volume of baryta-water. No blue, violet, or red color should appear in either stratum of the liquid. Such colors would indicate tar-constituents, which should not be present in creosote. If 1 vol. creosote is shaken up with 2 vols. of a 15 to 18 per cent. ammonia, a genuine pure sample takes, at most, a lemon-yellow color in the course of half an hour, and the upper aqueous stratum is pale or yellowish. Equal volumes of creosote and collodion should form a mixture which remains colorless for half an hour.—*Zeitschrift für Analyt. Chemie.*

* The specimen is slightly wetted, and the fibers separated and laid evenly on the glass slip with the help of a finely pointed needle.

THE FIXED OILS.*

By William Fox, F.C.S.

It is well known that animal and vegetable oils, on exposure to the atmosphere, become in time of a mucilaginous consistency, or in some cases are converted into solid masses. The length of time required to produce this change varies to a considerable extent with the different oils; linseed oil becomes quite solid in a few days, while olive oil only becomes slightly thick in several weeks. These two oils may be taken as the extremes in their power of absorbing oxygen, and it is to this property, a property possessed by (to some degree) all animal and vegetable oil, that this "drying" or "thickening" of the oil is due.

This property is explained in text-books by the statement that the oleic acid of the olive oil and the linoleic acid of the linseed oil possess a great affinity for oxygen. This I find not to be the case; neither oleic nor linoleic acids when pure absorb any oxygen, as the following experiments will show:

The acids were obtained by saponifying olive and linseed oils with caustic potash, decomposing with hydrochloric acid without using an excess, filtering, and washing with water at 100° F. The acids were then washed into a separating flask and taken up with dry ether; this was repeated several times. The ether distilled off, the acids were obtained without having been heated over 100° F., thus reducing the risk of their absorbing oxygen during preparation.

Weighed quantities of the acids thus obtained were then sealed up in glass tubes, and maintained at a temperature of 220° F in an oil bath for six days without absorbing any trace of oxygen, proving that the absorption of oxygen is not due to the oleic or linoleic acids present in the oils.

Thin strips of lead were suspended in the product obtained as described, without losing any weight, though the lead was in contact with the acids several days at 220° F.

While estimating the quantity of oxygen absorbed by olive oil, a great difference was noticed in several samples. This at first was supposed to be due to adulteration with other oils, until those samples which absorbed an abnormal quantity of oxygen were found to be rancid and to contain quantities of free acid. On heating these samples to 400° F., this free acid was expelled, and then the oil absorbed the same quantity of oxygen as those which were sweet and contained no free acid.

This I find to be the case with all the vegetable oils; the larger the amount of oxygen absorbed, the larger amount of free acid they contain.

It therefore follows that the absorption of oxygen does not depend on the oleic or linoleic acid, but on the products of the decomposition of these acids, other acids being formed which possess the power of absorbing oxygen and also of combining with metals or oxides of metals. Metals combine with these acids without giving off any hydrogen.

The action of the so-called driers—such as the oxides of iron, manganese, and lead—on being added to an oil appears to hasten the decomposition of the fatty acids, producing those acids having a tendency to absorb oxygen.

The insoluble fatty acids are lowered to a considerable extent by oxidation, the soluble acids being increased.

The quantity of a metal dissolved by an oil is not a measure of the free acid the oil contains, but proves whether the oil is one that will readily undergo decomposition. This is of importance in the examination of lubricating oils. Testing for and estimating the free acid in a lubricating oil is of no value as regards the liability of the oil to undergo decomposition, as the sample, if new, will be unlikely to contain free acid, though what it may do in time at present there is no means of showing.

This property of absorbing oxygen may be taken advantage of as to the liability of an oil to undergo decomposition, and thus affords valuable information as to the suitability of an oil to be used as a lubricant, its fitness to be used in the manufacture of varnishes and floor cloth, and as a test as to the purity of an oil.

The following I find a good method for the examination of lubricating oils:

About one gramme of the oil is sealed up in a glass tube having a capacity of about 100 c. c., with 0·5 gramme of precipitated lead. The whole is then heated in an oil bath for several hours at 220° F. The amount of oxygen absorbed is then estimated; this may be done by the decrease in the volume of the gas in the tube, or the remaining gas may be measured and the unabsorbed oxygen absorbed with pyrogallic acid and potash.

The less quantity of oxygen absorbed by the oil, treated in this manner, the better the oil for lubricating purposes. This method not only shows the presence of free acid, but also what the oil may be expected to do while being used in contact with metallic surfaces.

The only oils having no effect on metals and absorbing no oxygen, are properly prepared hydrocarbon oils. These oils far surpass all other oils as lubricants. Samples of mineral oils heated to 220° F. with precipitated lead absorbed no oxygen in twenty days; vegetable or animal oil so treated became quite hard in a few days.

In the manufacture of varnishes and floor cloth a great deal depends on the drying properties of linseed oil. This oil varies more than any other in its power of absorbing oxygen.

The following table will show the great difference in the power of absorbing oxygen possessed by a few of the more important fixed oils:

	C. c. of oxygen absorbed by 1 gramme of the oil.
Baltic linseed oil	191·
Black Sea " "	186·
Calcutta " "	126·
Bombay " "	130·
American " "	156·
Cotton seed oil (refined)	24·6
Rapeseed oil (brown)	20·
Rapeseed oil, Colza	17·6
Olive oil (highest)	8·7
Olive oil (lowest)	8·2

These figures are the means of a great number of experiments on different samples, closely agreeing with each other except in the case of linseed oil.

The great difference between the Indian and Russian seed oils will be noticed; the latter are the oils used for varnishes and floor cloth making. The Indian seed oil never becomes quite dry, but always remains "tacky."

The cause of this difference in the drying properties of linseed oil is generally understood, and is so stated in text-books, to be due to the presence of albuminous matter. This statement is made, I imagine, owing to the fact that when linseed oil is heated rapidly to 400° F. an albuminous looking matter separates. Oil made from seed grown in warm climates contains more of this substance than oil made from seed grown in cold climates, and the more of this so-called "albuminous matter" there may be contained in the oil, the lower the drying qualities of the oil. I have made experiments on oils containing large quantities of this substance, but have never been able to find a trace of nitrogen, either by combustion with soda lime nor by distillation to dryness with permanganate of potash.

I have separated, as well as possible, some of this substance from the oil, and from the results of two analyses it appears to be oleic acid—at least the hydrogen was too low for linoleic acid. It will be understood that, as linseed oil varies to such an extent, a test that will prove whether an oil is fit to be used for varnish and floor cloth making is of value to the manufacturer of these things.

The following method may be employed to this end:

50 c. c. of the oil is heated in a beaker, over a Bunsen flame, to 500° F., 2·5 grammes powdered and dried oxide of iron (Fe_2O_3) is then added, and the heating continued to 550° F., the burner is then withdrawn and the oil allowed to cool a little, then filtered through filter paper to remove any suspended oxide of iron. About 0·2 gramme (rather less than more) of the oil so treated is sealed up in a tube and oxidized in the oil bath at 220° F. The oxidation will be complete in about four hours; the oxygen left unabsorbed is then estimated by means of pyrogallic acid and potash.

I use a conical shaped flask, having a capacity of 200 c. c. and fitted with an accurately ground stopper. The flask is weighed, and as the oil slowly filters 5 or 6 drops are received in the flask, and the flask again weighed gives the amount of oil being operated upon. If the stopper be smeared with a little burnt India-rubber, any escape of gas is impossible. At the end of four hours the stopper is withdrawn under water, the gas measured in a eudiometer, and the remaining oxygen absorbed with pyrogallic acid and potash. From the data thus obtained the oxygen absorbed is calculated. Of course the usual precautions of gas analysis must be observed.

As first worked out by me, the oil was spread on a plate of glass, and the increase of weight owing to the absorption of oxygen weighed. This method does not work satisfactorily and, from the small quantity operated upon, serious errors were liable to occur. By sealing up and measuring the oxygen, excellent results are obtained.

The difference between the amount of oxygen absorbed by olive and cotton oil is greater, I think, than any difference hitherto observed between these oils. The only test of any value for the purity of olive oil is the "Elaidin" test—though this test is far from being satisfactory, as all tests must be that depend so much on the operator's judgment. By estimating the quantity of oxygen absorbed, the purity of the oil may at once be proved. Under no circumstances have I found pure and sweet olive oil to absorb more than 9 c. c. of oxygen.

Taking this figure as representing pure olive oil and 24 as cotton oil, the quantity of the latter may be calculated thus:

$$\frac{(A-9)\ 100}{15}$$ equals percentage of cotton oil.

where A is the number of c. c. O absorbed by 1 gramme of the oil under examination.

Working in this manner, the following results were obtained:

Olive oil containing 5 per cent. cotton oil absorbed 9·5 c. c. O, equal to 3·3 per cent. cotton oil.

Olive oil containing 10 per cent. cotton oil absorbed 10·4 c. c. O, equal to 9·3 per cent. cotton oil.

With 20 per cent. cotton oil 12·3 c. c. O was absorbed, equal to 22 per cent. cotton oil.

Containing 25 per cent. cotton oil, 13 c. c. O was absorbed, equal to 26·6 c. c. cotton oil.

If the oil under examination be at all rancid, it must first be heated to 400° F. before estimating the quantity of O the sample absorbs.

In concluding this paper, I regret not being able to more fully explain the changes which take place in the "drying" of the fixed oils. That the generally accepted idea is wrong there can be no doubt, and I hope before long to be able to throw more light on the subject.

Any investigation on oils must be carried out independently, as no text-books contain any information of value.

The subject is a very interesting one, and the ground for experiment and investigation unlimited.

That chemists have not paid more attention to the chemistry and properties of these complex class of compounds is singular, considering the large amount of capital, and the importance of the oil industry.—*The Analyst.*

* Read before the Society of Public Analysts, on May 30, 1883.

NARCOTICS AND STIMULANTS USED IN CENTRAL ASIA.

In the first rank stands the *nacha* or *hasheesh* of the Arabs. The nacha is prepared from the leaves and flowers of the hemp (cannabis sativa and c. indica). The narcotic principle is a gelatinous resin called *cherris* or *teharass* by the Arabs, and contained chiefly in the foliar glands. The nacha, as it is found in commerce, is a kind of dry paste, greenish in color, which resembles an oil cake. It is made by pulverizing the powder of the dry leaf with a little oil of sesame, or the leaves and flowers are boiled in water and crushed by the hand. The nacha is almost always smoked, mixed with tobacco in a water pipe. Only a small piece is introduced, which is previously powdered and heated. The nacha is also reduced to powder and mixed with powdered charcoal, which mixture is burned in the *tchilim*. At the bazaars there are *tchainika* or cafés for the special use of the smokers of nacha. To these cafés there is attached a person whose duty it is to draw the first puffs and start the pipe, an injurious operation from the charcoal gas emitted at the beginning of the smoke. Nacha can be readily procured from the dealers, but its sale is forbidden in the cities of Turkestan. The Russian soldiers, during the occupation of Tachkent, partook of nacha freely with sad consequences. The poor and indolent partake gladly of this revery-promoting drug, and forget under its stimulation their abject condition. In large quantities it is a poison, gives rise to delirium and fits of demented rage. Opium is its antidote. The smokers of nacha wet the head and drink sour milk.

The nacha is introduced into the system in yet another way. The leaves of the hemp are boiled in water; a volatile oil is disengaged, which floats upon the surface. This is collected and mixed with mutton tallow; it is heated a second time and an edible mixture is obtained, known under the name of *ravoghanikaïf*. The action of this latter is less intense than that of the nacha. It is mixed with sugar and then called goulkan, a confection for which the Sartian women have an especial fondness.

The natives also employ in the same way as nacha a drug called *mási*. That used under this name in Tachkent was prepared from the acorns of a species of oak, with their capsule mingled with the gall-nuts of the same tree. This drug is imported from Siberia, and possibly from India, as the oak does not flourish in Turkestan. The use of masi is relatively limited. The hemp is cultivated everywhere in Turkestan for its nacha, but the poppy is only raised in a few places, as at Karchi and Bokhara, for its dried pods, and not for the extraction of opium, such as the Chinese smoke, for instance. This latter is introduced as a contraband article from India by way of Afghanistan.

Under the name of *koknar*, the dried pods of the poppy are sold to be converted into an intoxicating beverage. The poppy is simply boiled in water. It relieves fatigue and ennui. The drinkers of this pernicious decoction begin by absorbing small doses, drawn along into wholesale consumption of it by an irresistible appetite. They are at length able to consume an extract of 400 grammes of poppy heads, the twentieth part of which would suffice to destroy any one not habituated to its use. The slaves of this abominable vice are in despair when deprived of their stimulant, a prey to apathy, and physically and mentally helpless. The use of opium is not spread through Turkestan among the natives. The Chinese of Kouldja and of the province of the Seven Rivers use it after the fashion of their country.

The contraband commerce in this drug is carried on clandestinely. It is sold under the form of red and black sticks; the former, called *tariak*, resembles the extract of aloes of our pharmacies; and the latter, called *kaïraktcha*, is a purified extract of the tariak by boiling and filtering. The native doctors say that the tariak is the residue obtained by evaporating to a sirupy consistency the solution of koknar. The eaters of opium introduce a little quantity of tariak in the mouth and swallow it with tea or chew it.

Tobacco is universally used in Turkestan. Nevertheless, a great difference in its use exists between the nomads and the inhabitants of the cities. The latter use it immoderately. The Kirghiz nomad scarcely knows of the nacha or opium, but smokes tobacco. The tobacco is smoked in the water pipe (tchilim or kaljane), which differs from the Persian narghila or the Indian houka in that the tube is made of a reed or of wood. Before the tobacco leaves are placed in the bowl of the pipe, they are moistened slightly by breathing upon them in the hollow of the hands.

In a large gathering the tchilim goes from hand to hand, beginning with the chief personage of the group. Each takes enormous pulls at the apparatus, which overcomes him for an instant and surrounds him with a thick cloud of smoke. The best smoking tobacco comes from Karchi and from Katti-Kourgane. There are two kinds, the green and yellow. The first is simply dried in a room protected from the sun, and the second undergoes a slight fermentation. The green tobacco is used for the manufacture of chewing tobacco. All, rich and poor, use it, carrying it about in their girdles in small gourds, and it is considered the height of rudeness to refuse it to any one desiring a portion of the coveted morsel. It is called *bossvoi*, from the Russian *nossvoï tabak*.

The most common drink is tea, the green, yellow, black, and tea of a brick tint. Enormous quantities are drunk, the natives being only excelled in this respect by the Russians. They drink it holding a chunk of sugar between the teeth. The yellow tea (kok-tchai) is the strongest, and, in large doses, causes nervous disorders. Coffee is almost unknown among the natives of Turkestan.

After cheriat, the Mussulman is permitted to drink of *moussalass*. It is but slightly heady, made from dried grapes infused in water. Strong alcoholic drinks are spreading among the populations in contact with Europeans. The nomad, who at best is a poor Mussulman, is addicted to two drinks, *koumyss* and *bouzah*. The koumyss of Europe bears but a slight resemblance to the drink of Kirghizes. It is made from mare's milk and it is difficult to obtain sufficient of this milk without having access to the herds of horses nourished upon the aromatic herbs of the steppes. Even the koumyss of the Kirghizes is mingled with cow's and camel's milk, and, indeed, often with water. The best koumyss is made exclusively from mare's milk, fermented in a goatskin sack, into which new milk is poured as new mares are milked, the whole being agitated from time to time, and kept inside the tents of the camp, exposed to an impure and heated atmosphere. A clear liquor results, foaming, sparkling, and very intoxicating, which the Kirghizes drink in incredible quantities.

The bouzah is a fermented drink, less intoxicating than the koumyss. It is made of millet and rice. The millet grains are put in hot water; when swollen introduced into a sack which is buried in wet sand. After four or five days the millet begins to sprout, then it is triturated, mixed with broken rice, and boiled. The mass is placed in a hot spot, in summer in the sun, in winter over a small fire, and after some days' fermentation, squeezed in a cloth, warm water being constantly added to the mass, until its strength is exhausted. This liquid is the bouzah, that is drunk hot or cold. Frequently a toxic drug, named *kouschala* or *kschela*, is added to the bouzah. Its action is analogous to that of nacha. Its sale is forbidden in the markets.—*Revue Scientifique.*

A HILL OF TREES.

A correspondnet of the *Country Gentleman* says, A friend of mine moved from the picturesque hills and lovely woods of western New York to a prairie country, treeless and level. Although at first he duly applauded his new home for its practical utility in being so level, and blessed his luck in having no stumps to pull, yet its monotony became unbearably wearisome, and he was homesick for a sight of rugged but beautiful Cattaraugus. Trees he had, for his first care was to plant windbreaks, and a ten acre forest of soft maples and cottonwoods; but hills were missing.

Finally he told his wife that he was "going to make a hill at least 100 feet high," about a thousand feet in front of the house. When I saw this hill it was nearly 75 feet high, and one of the most beautiful sights I ever saw.

This is the way it was made. In the center of a circular land about 200 feet in diameter he set a cottonwood tree, and 20 feet away a circle of 6 cottonwood trees. The center tree was much larger and thriftier than the circle. Twenty feet distant was another circle—this one of willows set 15 feet apart. Then followed catalpa, ailantus, Osage orange, and last holly. These outer circles were closer, and the trees being of smaller kinds were set closer.

By cultivation and manuring he endeavored to incite the central trees to a more luxuriant growth than the outer ones, and has succeeded in a remarkable degree. The result is a solid green hill of foliage that soon will be 100 feet high in the center, and slopes down to about ten feet at the base.

My friend tells me that he does not think he made the best possible selection of varieties, but could do better now in making a uniform grade.

My friend is "building" another hill on a modification of this principle. This is to be an evergreen hill, and for the place of honor he has a white pine surrounded by spruces, and the varieties graded as to size to the edge. To secure a greater hill appearance, he allows 5 years to elapse between the planting of the different circles, so that when the last circle is set the central tree will be 25 years old.

SCIENCE IN ANCIENT TIMES.

A GREEK TOY.

UPON a pedestal there is fixed a small tree around which is coiled a dragon. A figure of Hercules stands near by, shooting with a bow. Finally, there is an apple lying upon the pedestal. If this apple be lifted from the latter, Hercules will shoot his arrow at the dragon, and the latter will hiss.

Mechanism of the Toy.—Let AB be the water-tight pedestal under consideration, provided with a diaphragm $\Gamma\Delta$. To this latter there is fixed a small, hollow, truncated cone, EZ, whose apex, Z, points toward the bottom of the vessel, and from which it is just sufficiently distant to permit the water to pass. To this cone there is adjusted with care another one, Θ, which is fixed to a chain that, passing through an aperture, connects it with the apple. Hercules holds a small horn bow, whose string is stretched and placed at a proper distance from the right hand. In this latter, and facing the dragon, there is another hand exactly like the other, but smaller and provided with a detent.* To the extremity of this latter there is fixed a small chain or a cord that traverses the top of the pedestal, passes over a pulley fixed to the diaphragm, and connects with the small chain that joins the cone with the apple. This cord passes through the hand and body into the interior of Hercules. Finally, a small tube, one of those used for whistling with, starts from the diaphragm, rises beneath the top of the pedestal, and passes into the interior of the tree or around it.

Let us, then, bend the bow and place its string in the right hand, fix the detent, and arrange things so that the cord shall be taut and the apple be pressed against the surface of the pedestal, and let us fill the vessel, $A\Delta$, with water; let ΔM be the tree, $N\Xi$ the bar, $O\Pi$ the string, $P\Sigma$ the arrow, P the hand that clutches the string, Υ the detent, $\Phi\Pi$ the cord, X the pulley over which it passes, and, $\Psi\Omega$ the whistling tube.

A GREEK TOY.

Now, if the apple, K be raised, the cone, Θ, will be raised at the same time, the cord, $X\Phi$, will be tautened, the catch will be freed, and this will cause the arrow to shoot. The water in the compartment, $A\Gamma$, running into the compartment, $B\Gamma$, will drive out the air contained in the latter, through the tube, and produce a hissing. The apple being replaced, the cone, Θ, will adjust itself against the other, stop the flow, and thus cause the hissing to cease. The arrow and its accessories will then be adjusted anew.

When the compartment, $B\Gamma$, is full, it is emptied by means of a spout provided with a key, and $A\Delta$ is again filled as we have indicated.—*M. De Rochas, from the Pneumatics of Heron, in La Nature.*

* This internal hand serves as a catch for holding the cord and bending the bow. For this reason it is movable toward the wrist around a vertical axis. A small detent, placed between the two hands, causes the inner one to grasp the bowstring, and to free the latter when the detent is moved by means of the small chain.

MADAGASCAR.

A CORRESPONDENT of the London *Times*, writing from Antananarivo, the capital of Madagascar, says:

There has been much said lately in England about the enormous number of slaves in Madagascar, and the employment of slave labor by English missionaries. The latter practice is, on the face of it, not only to be condemned, but would appear to be an absolutely impossibility. That it does exist and is accepted more or less calmly as the inevitable, is a proof of the terrible hold which the slave system has taken in the minds of the Malagasy. Slavery is all but universal, labor is looked upon as a degradation, and consequently free labor is difficult and all but impossible to obtain. The fact is, almost every free person is a slave-owner, the exceptions being those who are too poor to possess slaves. We have occasionally had "free servants" in our employ but slavery has produced in their eyes such an utter degradation of work that they mostly turn out highly unsatisfactory. They are above doing this or that, and although they will in time do almost anything for us in the house, because they see that we consider no labor degrading, yet they will not think of carrying anything out of doors. A carpenter will not even carry a plank, and much less would he bear a palanquin or fetch water—the two latter being essentials of our life out here. These grand ideas naturally produce laziness, and thence stupidity, and thus it comes to pass that the slaves are often much more plucky, capable, and clever in every way than their masters. This state of things makes it up-hill work teaching, especially anything practical. Those who are willing to work learn, and thus, while we are toiling with a class, we find numbers of young fellows who are nursing their pride, and think it beneath them to use their hands.

As to the Mozambiques (imported Africans), these are a much-despised and down-trodden race, though some few have got rich and hold slaves. It will be remembered that these Mozambique slaves were set free by an edict of the Queen a few years ago. Some of these even intermarry with Hova slaves, with the sad result that their children are born into bondage.

Then come the Maromita. These are a class of slaves, men and women, principally men, who do odd work for anybody who will hire them. Their masters send them to dig their rice fields, or get them to carry them when they go to a marriage or a funeral, and make them pound mud with their feet when they are making a house or a wall. But, owing to the great number of the slaves, and the master not wishing to support his little army, he generally tells the Maromita to go out and get their own living, and this they do. Those that are very strong and pretty brave go to and from the coast, and get very good wages as palanquin bearers. Of course they keep their money from their masters, and so it gets all spent, sometimes in trade, often in drink. The rest sit about from morning till night on the graves along the roadside, and outside our gates, like the men in the parable, waiting for some one to hire them. They are an interesting class, with a life and a history of their own, apt to grow lazy and become an easy prey to temptation, but with some vigor of mind and even independence of character, as shown in their clannish ways of "doing" their masters if hardly used. As a rule, it is from this class that, without any recommendation, but simply from their own personal knowledge of them, Europeans draw now and then a regular servant as houseman, water-carrier, gardener, cook, etc.

FUR SEALS.

DID you ever hear of the Pribyloff Islands, or a snow spelled, Pribylov? Do you know where they are? You need not be ashamed to say no, nor take on that account reproach to yourself for unseemly ignorance of geography. You can scarcely find any map on which they are laid down, and though we propose to show that they are of no small productive value, yet not very many persons are even aware of their existence. But at all events you have heard of Alaska, and of that chain of mountains, the western extension of Alaska, which, as only their summits are above water, we call the Aleutian Islands. Well, there you are. Right out in that dismal, cheerless expanse of sea to the north of the Aleutian Islands—call it Behring's Sea, or, may be, the Sea of Kamschatka—enveloped in one mass of chilly fog, with but few breaks in it throughout the whole summer, there are the Pribylovs, about 180 miles north and a little west of Unalaska, lat. 57° N., long. 170° W., in round numbers.

There are but four of them, St. Paul's, St. George's, Otter, and Walrus, in order of size, and they are small—St. Paul's, the largest, being only 12½ miles long, while Otter and Walrus measured together cannot fill out a mile. The vegetation, from the climatic surroundings, is necessarily very much limited, no trees, no shrubs even, and the population is correspondingly small, only about two hundred in all, including the few white men who act as officers in charge. Of what importance then can such an insignificant region be to any one? Why is it worth while even to mention such barren little places, or to hunt them up on the map?

These seem like reasonable questions, but outside appearances are not always to be trusted, and these islands, petty as they seem, are up for our consideration at this moment because they are worth it, because there is *money in them*. If you paid to the Government $250,000 as your private tax, you would be very apt to consider yourself worthy of honorable regard in the community. St. Paul's and St. George's (the two small ones do not count) do that, and the hundreds of thousands which they pay to those who have them in charge we will consider by and by.

Come up with me and see the source of this rich return. Take your stand here by my side, and I will show you such a sight as I venture to say your eyes never saw before. We will not look inland, though the dreary barrenness would be to you, doubtless, a strange and impressive scene; the desolate wildness of that chill north-land no one knows till he has seen it. But we will look out seaward. We are on a low rocky shelf, with a smooth sand beach before us. The beach, which is about a mile long, curves gracefully in from a bluff point on our right, and out again to a similar one on our left, the two points limiting our view, and we are looking east and southeast. Charming breakers come curling on the sand, while beyond the line of foam the surface of the sea is quite smooth, and it would be everywhere unbroken were it not that it is dotted in all directions with round black objects. These objects are in motion, and it is easy to see that they are heads, and that they are coming toward the shore. Some are already among the breakers, and it becomes manifest that they belong to animals which are large and very strong, and which are just as much at home in the water as are fish themselves. The graceful ease and even majesty of their movements are delightful beyond description, being seen most remarkably in the perfect facility with which they not only resist, but actually utilize and control, the terrible swing of the surf. You see one right in the last, clear curl of one of the heavy ocean swells, where it begins to bend over and grow white with foam on its edge, as it prepares to come crashing down on the hard sand. Your experience of surf-landing makes you uneasy for him, as you are well aware that any boat in its present position would be within two seconds' reach of her own destruction, for when that breaker struck the beach, and she with it, the terrible blow would shiver her timbers at one crash. Perhaps you will do what I did the first time I saw such a transaction. I undertook to instruct him in his duty, not remembering that he had been there before and I had not. I held my breath at first, and then I fairly shouted to him: "Look out, there, old fellow, look behind you! That sea will smash you!" for a mighty roller was cresting up above his back ready to strike, and I thought that he had not noticed it—that for once in his life he had made a mistake, and was *gone*, sure. Well! He was gone, it is true, but it was not in the way that I supposed. How many times, since that, I have laughed to think what a fool I was to imagine that I could instruct one of these kings of the surf in hydrodynamics. And yet it would be hard to find a more surprised individual than I was to see the close of the transaction. No words can represent the perfectly astonishing majesty and grace with which one sweep of his hind flippers placed him in absolute control of the situation; the raging surf was only his subject. He was the king. The breakers crashed and melted, and smoothly and quietly in the midst of the subdividing foam a noble *seekatch*, six to seven feet in length, stepped out on the sand as composedly as may be, and came toward me.

But majesty and grace pertain to him only while in the water, for as he comes up across the beach he is clumsiness personified. And the beach being by this time covered with hundreds like him, the sight is, as I told you, a strange one. For we are on the Island of St. Paul's, this is Lukannon Beach, and these are fur seals "*hauling*"—a singular term applied by the sealers to that peculiar time and act at which we have been looking, the annual landing of the fur seals here and on the Island of St. George.

Who does not know the fur? No one. Who does know the animal? Very nearly the same answer might be given, but we will be more complimentary, and say—not many. The fur is beautiful, so fine, so rich in appearance, that it is a universal favorite. It takes and retains a dye so perfectly, while other dyed skins fade and grow dingy, that it keeps persistently its hold on the market. While fashion rules other furs *out*, seal is always *in*, and perhaps will always continue so, for it is one of the few furs of which according to present appearances we may be tolerably sure of a steady and permanent supply; it is not on the road to extermination, and we will look now to see the reason why.

When fur seal skins were first brought into the market, and for many years afterward, the main supply came from the Southern Hemisphere. The groups of wild, rocky islands, east and southeast of the southern part of South America, the Falkland Islands, the South Shetlands, and all the other wild and almost inaccessible rocks in that vast Southern Ocean, were found, on their first exploration, to fairly swarm with fur seals. As the skins proved to have so much value, expeditions almost without number were fitted out to engage in their capture, and the returns were eminently satisfactory. But it was not only toward the Antarctic circle that the hunt extended, for fur seals were found to be abundant in the high northern regions as well.

As an item in zoological history it seemed singular that a species should have such a wide distribution as from the South Shetlands to the Pribylovs, 60° S. to 58° N., almost two-thirds of the distance from pole to pole, and yet fur seals were killed abundantly at the two extremes. Subsequent examination, however, has shown that they are not of one species. The Southern fur seal is the *Arctocephalus falklandicus:* the Northern is the *Callorhinus ursinus*. We may dismiss the *Arctocephalus* from the discussion entirely. Persecution, without any restraint being imposed, has so nearly exterminated the race that active hunting for them has ceased, and for years past the only fur seals have been those of the *Callorhinus;* and so thoroughly narrowed has the range of even this single species become that we have seen a large proportion of all its numbers as we have stood and watched on the bluff of Lukannon Beach. It is this very restriction in limits which is about to prove the means of their preservation and perpetuation.

Until within a few years the Northern fur seal ranged from these Arctic regions almost to the equator. They were numerous all along the coast of California, and twenty-five years ago the hunting from Point Conception down to Cape St. Lucas was a source of much profit. Steadily and rapidly they were swept away, until practically none are left. While the Russians held Alaska and the adjacent islands the same work went forward, and within a little while, perhaps even by this time, fur seal hunting, as a business, would have ended, being reduced to the few random skins secured by Indians. But fortunately this process of extermination has been arrested. After the purchase of that region by the United States a wise step was taken, and one on which we may well felicitate ourselves, for our Government has done but little for the preservation of either beast, bird, or fish within our domains. And undoubtedly the action in the present instance was originated and completed mainly because of private enterprise. A few men had the wisdom to see that in the preservation of the fur seals there was an opportunity to secure a permanent revenue to themselves while they paid at the same time a steady revenue to the Government. Accordingly, "An act to prevent the extermination of fur-bearing animals in Alaska" was passed, bearing date of "Approval, July 1, 1870." Its object is the protection of the fur seals on the Pribylovs. The Alaska Commercial Company was formed, having for its first president Gen. John F. Miller; its place of business, San Francisco.

Under their enlightened and energetic control the seals are secure from indiscriminate slaughter. None are allowed to be killed except in June, July, September, and October; no females and none under a year old at any time; no fire-arms are allowed; nothing else which can alarm the seals or drive them away. The number allowed

to be taken annually, except such as the Indians kill for food or for skins to use, must not exceed 100,000; 75,000 on St. Paul's, and 25,000 on St. George's. This amount of depletion experience shows that the islands can bear without diminishing the supply, and in fact it is manifest that the yield could safely be increased should the market require.

The company pay to the United States a rental of $50,000, with two dollars additional for each skin taken, thus making $250,000 as mentioned. Their lease from the Government extends twenty years from May 1, 1870, with provision for renewals of other terms of twenty years. Of course they practically monopolize and control the fur seal trade, for the number of skins gathered here and there as stragglers by the Indians down on the coast of British Columbia, Washington Territory, and Oregon amounts to but a few thousands at the most, not enough to have any effect on the market.

It is scarcely right to omit here a notice of the manner in which they have treated the "Indians" inhabiting the islands. These people are not at all Indians in our common use of the term. They are of a very mixed character; probably not a single full blooded Aleut among them, and like all such mixed races, of low grade. Before this company took possession, they lived in low, sod-built huts, partly underground, damp and dismal, and had largely blubber for fuel, whose black, grimy soot covered everything, and the moral elevation of the people was in accord with their habitations. Now they have stone houses, dry and warm, and are furnished with coal regularly by the company. Their personal rights are protected, their children are furnished with instruction. It is true they make out to brew a *beer*, from sugar, flour, rice, etc., and at their dancing parties drink it to intoxication, but they are by no means the drunken, degraded beings they formerly were. And too great honor can scarcely be given to the Alaska Company, for very few have been the instances in which a people of inferior grade have been treated so justly and humanely by those who became their rulers.

The fur seals are inhabitants of the Pribylov Islands for a period of a little more than half the year. The first arrivals from the South are about the first of May, and almost all have departed by the middle of November. During the winter they are probably widely dispersed over the North Pacific, for it is tolerably certain that there are no gatherings of them at any place, or over few places, sufficient to account for the vast swarms seen here.

The old males, the seekatches, arrive first, coming through all the month of May. A full grown seekatch is a mighty and noble looking beast. His length is seven to seven and one-half feet and he weighs from 450 to 600 pounds. Strength and boldness are in every look and motion, and he is just as ready for a quarrel as he appears. At this season fighting is his normal state and condition, and pretty much the whole of May finds him busy. They gather at certain spots called "rookeries," one of the largest of which is here at Lukannon Beach, where we saw our friend landing.

As he stepped out on the sand, his free and easy manner told plainly that if a quarter section were not already staked out for him he meant to have one any way. He knew that the good old border law says that "he may take who has the power, and he may keep who can," and so up the beach he goes The whole front line of the rocks is already pre-empted, a seekatch to about each ten feet, but that makes no difference in his plans. He selects the particular "claim" that suits him, and with a savage roar he plunges at its occupant and the fight rages fiercely. He is too strong for his adversary, who retires ignominiously away to the rear to find a new position.

But how long will the new-comer hold his place quietly? Possibly not an hour. His near neighbors will probably not molest him, for they are already settled, but the very next arrival from the sea may be bold enough to "tackle" him, and so it goes, and within two weeks, if he is strong and fierce enough to keep his ground, he will probably fight from thirty to sixty battles. His head and breast will be a mass of gashes and scars, very possibly an eye gouged out, but never mind, the chip is on his shoulder still, and he is just as ready for a fight as ever.

By the last week in May the seekatches have all arrived and settled themselves according to their ability. The "rookery" has then about one to each ten feet square of all the rocky surface, extending from ten to twenty spaces broad. In each of these a seekatch is waiting patiently for the arrival of the clapmatches, the females. About the first of June they come, and as they greatly exceed the males in numbers the sea is fairly black with them. But as they come through the surf, what different looking objects we see! Instead of the strong, fierce beasts we have had before, a clapmatch is a gentle little thing, weighing not over eighty pounds, and with a peculiarly mild and peaceable aspect.

As the ladies step out in swarms, every gentleman, especially each one in the front pews, is on his best behavior, hoping to entice just as many as possible of the clapmatches into his harem, for the seekatches are the most thoroughly polygamous of all animals known. We will give our attention to our former friend, whom we will call No. 1. At the first, all goes nicely, and he secures two beautiful little clapmatches without difficulty. But in a few minutes he sees another coming up, and all his care and blandishments are expended in coaxing her to step in also. But while he is thus busy, he experiences a domestic bereavement. No. 2, in the pew directly behind his, reaches over with his long neck and picks up one of the quiet little clapmatches, already settled in No. 1, precisely as a cat picks up a kitten, and drops her gently in his own domain. All right for No. 2, but No. 3 and No. 4 are fired to madness by the high-handed outrage, and forthwith "pitch into" one another and especially into No. 2, and in the midst of the row No. 2's clapmatch is picked up by No. 5, behind him, and the fight spreads, and very likely in a few minutes she has been taken up in the same way, and put over in may be No. 10. It is a strange sight, and the work goes steadily on, fighting in this manner for about three weeks or as long as the clapmatches continue to arrive. But early in July all has become quiet. By that time each seekatch has as many as he has been able to secure and retain, generally from five to twelve. One venerable old patriarch I recollect had forty-five by actual count, but topographically he had a special dispensation in his favor; he had them penned up on a flat ledge to which there was no access except by one narrow neck, and that he guarded safely.

The clapmatches seem most contented when closely packed, and it is I think a moderate estimate that a "rookery," when fully occupied, holds one seal to each two feet square of space. And even this number is speedily doubled, for the young are born very shortly after the arrival of the clapmatches, one to each mother. Queer little fellows these pups are, regular curiosities; about three pounds, and just as black as the ace of spades. Their voice it quite like that of young lambs, and it often sounds as though a large drove of sheep were collected at the "rookery." They gather in "pods," of fifty or sixty, and like other babies their only business is to eat and to sleep. Their mothers go off into the sea and only come on shore to nurse them.

Each seekatch continues to occupy his harem, the one spot on the rocks, from the time of his taking possession at the commencement of the season till he leaves it at the close. This is in no instance less than two months, and with many it is nearly four. During this whole period they do not enter the sea, and they absolutely *take no food whatever*, a fact to which I know no parallel in the entire animal kingdom. They take no food, and their bowels do not act. If they were quiescent, in a hibernating inactivity, this might seem less remarkable, but it is on the contrary their time of most intense excitement and vigor, and, wonderful as it is, their vitality must be maintained by the absorption of their own fat. This statement is almost beyond belief, but it is strictly true and too well substantiated to allow the slightest doubt of its accuracy.

The securing of the skins is not done at random; it is all under rigid rules. The selected animals are driven over to certain slaughtering grounds which are at quite a distance from the "rookeries." These chosen ones are mostly the males between three and five years of age, their fur being better than that of the old seekatches of the "rookeries,"—or of the females. These young males—"ballus-chickies" the natives call them—are not in the "rookeries." They "haul" by themselves on other parts of the beach. A few of the native men, creeping between them and the sea while they are asleep, start them with a shout and the timid animals hurry off. The men follow quietly, and separating the ones they select, they drive them without any more trouble than sheep would give to the slaughtering ground, where they are killed by blows from heavy clubs.

Under the rules and with the precautions here indicated, experience shows that the seals return each year in undiminished numbers and with continued boldness, the present seal population being about 5,000,000. The principal market for the skins is London. They are worth to the Alaska Company in San Francisco from $5 to $9, averaging probably a little over $7. It will readily be seen that deducting the amount paid to the Government, together with the expenses of capture and transportation, a very handsome profit remains.

The process of dressing the skins increases their value greatly, the dressed skins selling for all prices ranging from $15 to $45 in common, and from that up to any fancy price for those of special beauty. The process of dressing is not made public. It is a business secret held, so far as I am aware, by only a single firm in this country, and but a very few in London. It is certain that one part of it consists in removing the coating of long hair which clothes the entire animal, and leaving the dense mat of fine fur which is nearest the skin, and which is the only thing that we see in the fur as made up for use. The process is long and tedious, requiring great mechanical skill; it is said to occupy at least two months in its various operations.

THE AUSTRALIAN DUCKBILL.

By Dr. G. A STOCKWELL.

OF all odd, incongruous creatures, the palm is borne by the mulligong or lambreet, sometimes known as "water-mole"—an animal with the feet and bill of a bird, and body of a quadruped; and its scientific designation is nearly as threatening as its appearance is unique—*Ornithorhynchus paradoxicus*, or in plain English a "paradoxical bird-snouted" creature. Imagine if possible a small, flat, otter-shaped body from thirteen inches to half a yard in length, covered with a heavy coat of dusky-brown fur; a pointed, egg-shaped head terminating in the flat beak of a duck; four short, broad, webbed feet with scarcely any legs worth mentioning, the fore ones with the web, projecting *beyond* the claws, the hind ones the reverse, and also with spurs like a game cock; a brief, broad tail neither like that of the beaver or of the deer, yet something between the two; put all together, and then a faint idea may be had of this quip of nature and the appropriateness of its title.

Australia may well be termed the "Wonder Land" since in no other part of the world can be found such a menagerie of strange animals and jumble of odd names as here. There are wombats, echidnas, porcupines, bandicoots, koulas, bettongs, chœropi, phalangers, peramales, phascogales, sugar squirrels, devils, zebra wolves, opossums, tarsipes, tapoa-taphas, dasyures, petaroos, wha-tapoa-roos, and heepoona roos, besides kangaroos of all forms, sizes, and colors—long-tailed, short tailed, brush-tailed, nail-tailed, black-tailed, rat-tailed, and possibly without tails, though such have not yet been heralded; and rat kangaroos, mouse kangaroos, hare kangaroos, deer kangaroos, antelope kangaroos, rock kangaroos, and kangaroos and kangaroos *ad infinitum;* all of whose queer names are indicative of queerer habits, and each and every one, strange to say, a member of that peculiar family or group known as marsupial or pouched, and all, if not absolute denizens of the great island continent, at least inhabitants of the group of which it is chief.

It is said that the first specimen of the duckbill or *ornithorhynchus* ever presented to a naturalist was regarded by him as a hoax (and with little wonder), and called forth the remark that he had before viewed specimens of "Japanese architecture," having reference doubtless to those odd specimens of Japanese handicraft sometimes exhibited in museums under the title of mermen or mermaids, wherein the body of a monkey is so neatly and accurately joined to that of a fish as to defy any but the most careful and expert scrutiny.

In habits the duckbill is a representative of the beaver and muskrat tribes rather than of the watermoles, whose name it has usurped by grace of the English settlers. It is an amphibious animal, yet exhibits a marked preference for water over land, since on the latter its movements are somewhat restricted and awkward, owing to its peculiar form. It is even less graceful than the ducks or penguins, and moves about much as these creatures might be supposed to do were they given four legs in place of two. When diving, the tail is made to give the same loud flap so significant of the beaver, and appears to answer much the same purpose in steering while swimming, and as a prop when sitting upright upon its haunches it is also marked, though in a less degree, by rough scales and long scattering hairs, giving a half naked or mangy appearance. Of houses it builds none, but is a subterranean mammal, excavating for itself laborious burrows in the banks of such ponds and streams as it is wont to frequent. These passages are quite similar to the tunnels of the mole, but more extensive, though with fewer ramifications, reaching oftentimes for forty, fifty, and even eighty feet, sloping gradually upward from an entrance beneath the water, and winding and twisting in a most tortuous manner until they terminate in a blind pouch or *cul de sac* just beneath the sod. Commonly two openings are provided, the second away from the water some distance, and hidden by some convenient clump of bushes, tuft of verdure, or heap of rocks; and somewhere off from the main passage, usually equally remote from the openings and extremity of the burrow, is a short lateral passage leading into a snug and comfortable apartment duly lined with dried grasses, leaves, or weeds, which constitutes the nursery and lying-in-room of the female, and to which she always retires with the first pangs of maternity, remaining hidden therein until her offspring have grown to a size sufficient to in a measure care for themselves.

The youthful ornithorhynchi when first ushered into the world are blind, naked, and helpless enough, being scarce so large as a common mouse, and present perfect pictures of comical ugliness with their long, flat snouts, even longer than their heads, and tongues too large for their mouths, a condition of affairs rendered necessary in order to allow them to draw sustenance from the maternal fount; otherwise they would be in the position of a duck with a baby's nursing bottle. In a few days the little fellows have the use of their eyes, are clothed with a coat of soft, fine, mouse-like fur, and take to the water as naturally as the offspring of their feathered god-parents. Once admitted to the stream, they become as frolicsome as young kittens, are ever restless and brimming over with fun, now gleefully splashing, tumbling, and diving, then dragging some unfortunate wight, who has ascended for a breath of fresh air, beneath the surface by a tug at his tail, and indulge in high-jinks generally. In captivity they quickly become reconciled to their lot, enjoy the run of the house, and are generally mischievous. During the day they pass their time in alternately sleeping and eating; but with the first glamour of twilight they are out and around, rolling and tumbling about like so many puppies. Any strange article or new piece of furniture at once attracts attention, and must be duly nosed, climbed over, and gravely inspected ere they will be content. They are very fond of poking about in odd corners and unaccustomed places, and of making new acquaintances; and though naturally of a retired and timid disposition, soon make friends with the ordinary domestic favorites if so permitted; yet withal, if allowed free scope, they soon become most unmitigated nuisances. Mr. George Bennett, during several years' residence in New South Wales (Sydney), kept in his possession a number of young duckbills, feeding them on milk and soaked breadcrumbs. But between the youngsters and the annoying visits of the curious he led such an unpleasant life that he was obliged to dispose of the former in order to get rid of the latter. His pets, in spite of their ungainly forms and clumsy appearance, would manage to climb with some readiness to the summit of his book case, a distance of seven or eight feet; and under favorable circumstances such feats were performed even with considerable celerity, the ascent being made by placing their feet against the case and backs against the wall, lifting themselves by means of the powerful muscles of the back and claws. No special affection was manifested for deep water; but a bath in a shallow pan with a tuft of grass placed in the corner was always a source of great enjoyment, though they seldom remained immersed more than ten or fifteen minutes at a time.

Adult animals do not take naturally to attempts at domestication, and are less easily reconciled to confinement; and they cannot be allowed any but the most moderate of privileges, and then only under constant surveillance, since they injure floors and walls by vicious and persistent attempts at burrowing him. Three old animals in the possession of Mr. Bennett were kept by him in a cask filled with grass, mud, and water, and though they eventually became in a measure contented, they were always more or less restless, and exhibited none of the amusing ways of the younger ones. On one occasion he took an old female to an adjacent pond to indulge her in a swim, and to witness her performances, first taking the precaution to secure her by a cord about one of the legs. When placed on the bank she seemed a little disconcerted, but soon found her way into the water, where she rolled and plunged about in apparent delight, and then started on a voyage of discovery up stream, exploring those places where aquatic weeds were most abundant. When diving in deep and clear water, her motions were distinctly seen, and she sank easily and speedily to the bottom, apparently without exertion, as if by sheer weight of body, and after swimming a short distance would again rise to the surface, only to repeat the performance, and this occurred again and again without apparent motive; at the same time she kept close to the bank, into which the long beak was occasionally thrust up to the very nostrils, and then withdrawn with a mouthful of mud; and finally when tired she came out on to the grass and set to work combing and cleaning her coat with the hind claws until she had greatly improved its sleek and glossy appearance.

The fur of a full grown animal is very thick and soft to the touch, but by no means long, and when wet gives forth a peculiar, disagreeable oily odor. It consists also of two distinct coats, as it were: one an under one of exceeding softness and fineness, but dense and oily; the other, the outer, longer, coarser, and quite inclined to harshness, the individual hairs composing it somewhat pointed, with the last half bent at an acute angle, so as to stand nearly upright, while yet covering the finer fur beneath. In this arrangement we see a beautiful adaptation to the burrowing and aquatic habits of the animal: when burrowing, were the larger hairs equally stout from base to point and directed toward the tail, as in most quadrupeds, they would impede and incommode the wearer while moving backward; but by being slender at their bases, and expanded at the extremities, the points readily accommodate themselves to any surface with which they may come in contact; and lying flat on each other as they do, serve to keep out water or earth, and avoid the soiling of the finer fur beneath.

The most striking feature of the animal, and the one in which most interest is centered, is the peculiar horny and beak-like formation of the toothless mouth, that causes it to so exactly resemble the flat and sensitive bill of some lamellirostral birds—an anomaly of form and structure that, however, entirely harmonizes with the character of its food, which consists exclusively of aquatic insects, larvæ, mollusks, and other small invertebrates, such as conceal themselves in the soft and clayey margins of watercourses. Twilight is the hour at which the ornithorhynchus feeds, and it knows full well how to find those forms acceptable to its palate. Now it may be seen swimming about leisurely and silently with its queer little body all but submerged, presenting an appearance much like the musquash when on a foraging expedition. After moving about for a while in an apparently aimless manner, it suddenly dives toward the bank, into which it thrusts its horn-like

mandibles, and seizing a mouthful of clay retires a step, throws back its head, and with the peculiar "gabbling" motion of a duck feeding in a dirty puddle, strains out the food from the mingled water and earth and conveys it to the two little pouches with which it is provided, one in either cheek, there to be retained until the required supply for the evening meal is obtained. Again and again it charges the bank, stirring up the mud with vigorous movement, each time going through the same pantomime, until the cheek pouches are finally distended to repletion, when it floats leisurely down the stream or retires to its burrow to enjoy and digest the product of its labor.

We say the duckbill has no teeth; but this is not altogether true. To be sure, he exhibits no structures of bone and enamel as found in other quadrupeds, but we do find at the base of the tongue six rudimentary protuberances that doubtless may serve as teeth; and there is also an excrescence on each side of either jaw of the same horn-like substance as the bill, that would seem to do duty as grinders or molars in crushing and macerating food preparatory to swallowing. There are ridges, too, placed transversely along the roof of the mouth in the same way as in the upper mandibles of many water fowl; but these in no way aid manducation, as their sole office is the trituration and separation of the clay, whereby the small crustaceans are strained out, and the useless material allowed to escape from the mouth.

Native Australians hunt the ornithorhynchus for food, and esteem it a delicacy, more especially half grown, and newly born little ones. This, however, is no particular recommendation or proof of gustatory excellences, since nothing scarcely comes amiss to these savages in the way of diet, as they likewise affect mice, frogs, toads, lizards, grubs, snakes, and parasitic insects of all classes, which they devour raw or half cooked with as much gusto as a roast of savory bandicoot or haunch of kangaroo venison. They never attempt the capture of the species while swimming, or in the water, but await its retirement to its burrow, its presence therein being readily determined by the spoor at the entrance, and then proceed to dig it out by means of sharp sticks; this is done by making a number of exploratory excavations until the burrow is found and its line determined, when it is opened at its terminus, old and young dragged forth, summarily knocked in the head, and devoured with little cooking or ceremony. Some whites likewise affect the flesh of the animal as a luxury, claiming it to be most nutritious, easy of digestion, unsurpassed for broth for invalids, and extremely strengthening to the stomach; but for my part they are welcome to their tastes and opinions—I would none of it; and in my humble opinion it demands an excessively strong, rather than a weak, stomach to receive or relish it. Bandicoot is good; kangaroo is better; wombat may be eaten on an emergency—but preserve me from *ornithorhynchus!*

Port Huron, Michigan.

ON THE CAUSES OF GLACIER MOTION.*

By WALTER R. BROWNE, M. Inst. C.E.

THE question of the causes which produce the movement of glaciers, which was at one time so eagerly discussed, would appear to have slumbered for the last ten years. This cannot be said to arise from the fact that a perfectly satisfactory theory has been developed, and recognized as such by all inquirers. The ambiguous allusion to the subject in Sir John Lubbock's presidential address to the British Association is an evidence that such certainty has not been attained. It is indeed generally supposed that the fact of the melting point of ice being lowered by pressure is somehow at the root of the matter; but a full explanation of the origin of this pressure in the case of glaciers and of the mechanical features of the problem has yet to be given. I may therefore be pardoned if I draw attention to a different solution, proposed not by myself, but by one of the greatest of English mechanicians. My apology for doing so is that I approach the question as an engineer, not as a physicist; and that it is in its essence, as will be shown immediately, a mechanical rather than a physical problem.

The following are leading facts of glacier motion which must be accounted for by any valid theory on the subject:

1. The phenomena of the movement of a glacier are simply those of a solid body in a state of flow.

2. The present glaciers of Switzerland and Norway, which are the only ones which have been critically examined, are mere shrunken fragments of the glaciers of the Great Ice Age. To take one instance, the present glacier of the Rhone is about 6 miles long and perhaps 500 feet deep; but the old glacier of the Rhone, which abutted against the Jura, was 120 miles long, and must have been 2,000 to 3,000 feet deep. The movement of such glaciers as this must also be accounted for in any satisfactory theory.

3 The glaciers of the present day are not confined to the temperate region; they are found in much larger numbers and of much greater size in the Arctic regions.

4. Both in the temperate and in the Arctic regions glaciers move in winter as well as in summer, and by night as well as by day.

That a glacier is in a state of flow was first proved by Forbes, and has since been confirmed by the measurements of Tyndall and others. While the whole mass moves downward, the top moves faster than the bottom, and the sides than the middle; the upper layers must therefore be continually shearing over the lower, and the medial over the lateral. A glacier, being a body in a state of flow, must move under the influence of forces powerful enough to overcome its resistance, and so produce this condition.

The general phenomena of the motion of a glacier are exactly reproduced when a viscous body moves through a channel under the influence of its own weight. We have therefore first to inquire whether the shearing resistance of ice is sufficiently low to enable us to regard a glacier as a viscous mass.

The only experiments known to me on the shearing resistance of ice, are those of Moseley (*Phil. Mag.*, January, 1870). He found that with pressures from 100 to 110 pounds per square inch, cylinders of ice sheared slowly across the two planes in contact, sliding over each other without losing continuity. The distance sheared through was about five-eighths of an inch in half an hour. A load of 119 pounds per square inch was sufficient to shear through a cylinder of 1½ inches in diameter in two to three minutes. From these experiments it would appear that the lowest shearing stress which will cause ice to flow is about 100 pounds per square inch; but sufficient time was not allowed in the experiments to make this a matter of certainty.

There is another way in which the shearing resistance of ice may be tested. In the case of a block of ice of vertical sides, gravity of course produces a shearing resistance along all planes passing through the base. Let h be the height of such a block in feet, and consider the shearing force due to gravity on any square foot of a plane making an angle θ with the vertical. This shearing force is given by

$$\frac{wh \times h \tan\theta}{2} \times \cos\theta \div h \sec\theta = \frac{wh}{2} \sin\theta \cos\theta.$$

This expression is a maximum when $\theta = 45°$, and its value is then

$$\frac{wh}{4}.$$

What is the greatest height at which a vertical cliff of ice will stand? I am not able to state this precisely, but it is very considerable. Mr. Whymper mentions crevasses in South America 300 feet deep. Cliffs of fully that height have been seen standing out of water in the case of icebergs, and as so small a part of an iceberg projects above water, these cliffs probably extend below to a considerable depth. Taking, however, only 300 feet for the value of h, or for the maximum height of an ice cliff, this would give about 30 pounds per square inch as the lowest shearing force upon a plane of ice which would cause it to assume the condition of flow.

Let us now suppose a glacier of thickness a, lying upon a slope whose inclination to the horizontal is β; then the force per square foot tending to shear the ice at its junction with the slope is clearly $aw \sin \beta$.

Supposing $\sin \beta$ to equal ¼, and that the shearing resistance is 30 pounds per square inch, we get $a =$ about 290. Hence we may say that a glacier lying on a slope of 1 in 4 will not move at all under its own weight unless it be at least 300 feet thick, and that, if it be more than this, the upper 300 feet will move as one solid mass, the part below alone representing the conditions of flow.

It is needless to say that there are hundreds of glaciers which are less than 300 feet thick, and which at no part of their course have a slope anything approaching 1 in 4.

We have now to show that the theories generally propounded for glacier action are all of them negatived by some of the foregoing considerations. These theories may be stated as follows:

1. The glacier simply slides over its bed as a solid body. This is negatived by the fact that some parts move faster than others.

2. The glacier flows under the action of its own weight, exactly as a viscous body flows. This is the theory of Forbes. It is disproved by the facts given above, which show that even on a slope of 1 in 4 a glacier would not flow unless it was at least 300 feet thick.

3. The glacier moves by the crushing of its base. This has been disproved by Moseley's experiments, which showed that the crushing resistance of ice was considerably higher than the shearing resistance.

4. The glacier moves by the melting of its base. This is the theory of Hopkins. He placed a block of ice at 32° F. on a slab at a small angle, and found that it slowly descended as it melted. On this view the bottom of the glacier must always be in a melting state. But glaciers are of all sizes and thicknesses, and they move in winter as well as summer. Bessels ("Die Amerikanische Nordpol Expedition," p. 398) measured the motion of an Arctic glacier (not apparently very thick) in the month of April, which is just when the winter cold would have sunk deepest, and found it considerable. Again, in the *Zeitschrift des Deutschen Geologischen Gesellschaft*, vol. xxxiii., p. 693, is an account of measurements of a Greenland glacier, both in winter and summer, which show that the motion in winter is only 20 per cent. less than in summer. It has been suggested to me that the interior heat of the earth may be sufficient to keep the bottom of the ice from freezing; but this cannot apply near the sides, where the ice is shallow, and the freezing of a very small strip on each side would be sufficient to keep the whole mass from descending. Moreover, this cause would apply to masses of snow as much as to ice. But it is known that masses of snow, though lying on steep slopes, do not descend in this way, even in summer, but melt away where they lie.

5. According to the theories of Tyndall, Croll, and others, the glacier moves not in the form of ice, but of water. These theories are based on the known fact that the freezing point of ice is lowered by pressure. Hence it is supposed that certain parts of a glacier are continually being exposed to so much pressure that they melt. The water escapes downward, and the pressure being relieved, it freezes again. The continuity of the glacier is further kept up by the process of regelation, according to which two pieces of ice, if placed in contact, form into one solid mass.

The advocates of this theory hardly seem to consider how very small the lowering of the freezing point is for any ordinary pressure. It is only 0·0075° per atmosphere. In other words, it will require a pressure of 2,000 pounds per square inch to liquefy ice at 31° instead of 32°. This is equivalent to the weight of a column of ice about 5,000 feet high. It is needless to ask whether such a pressure can exist within an ordinary glacier, while on the other hand glaciers undoubtedly move at temperatures far below freezing point—in the Arctic regions below zero.

It seems to be generally supposed that the pressure in the lower part of a glacier is due to the steeper upper portions; the glacier channel is spoken of as a mould, through which the ice is forced by pressure from behind. But in the upper glacier, slopes of ice or *neré* are not uncommon at angles of 30° or even more. Such slopes usually do not even touch the more level parts of the glacier below them, but are separated from them by a wide, deep crevasse called a Bergschrund. Of this the well known ice wall of the Strahleck is a conspicuous example. In other cases such slopes do not end in a glacier at all, but die away upon the mountain side. It is certain, therefore, that ice or *neré* is able to maintain itself at a high angle upon its slope of rocks, and therefore cannot possibly exercise pressure upon the parts of the glacier far in advance of its foot. The fallacy of this idea may be further illustrated by referring, not to modern glaciers, but to those of the Great Ice Age. Can we suppose that the pressure of the snows about the sources of the Rhone was sufficient to drive that glacier down the Valley to Martigny, round a sharp angle to the Lake of Geneva, through the bed of that lake, and on to the slopes of the Jura, a distance of more than 100 miles, in which the average slope was about 1 in 200, giving a propelling force per ton of ice of about 11 pounds only?

All these theories have this in common, that they regard gravity as the sole and direct agent in the movement of glaciers, and the above considerations seem to prove that it is an agent far too weak for the work it has to do.*

The only other agent which has been suggested, or seems likely to be suggested, to account for the motion of glaciers, is heat. This suggestion, as is well known, is due to the late Canon Moseley, F.R.S., and was to some extent worked out by him in papers published in the *Phil. Mag.*, 1869 and 1870.

The mode of operation on this theory is well known. Ice is here considered merely as a solid body, obeying the ordinary laws of expansion and contraction under differences of temperature. This it is known to do, the coefficient of linear expansion for 1° F. being 0·00002856 (Moseley, *Phil. Mag.*, January, 1870), which is very high. When a mass of ice, such as a glacier, suffers a rise in temperature, either through conduction or radiation, it will expand; this expansion will take place mainly in the direction where movement is easiest, that is, down the valley. If from any cause the temperature falls, the glacier will again contract; but since the expansion is assisted by gravity, while the contraction is opposed by it, the latter will be somewhat less in amount than the former, and when the ice has returned to its original temperature, its center of gravity will have moved a certain small distance down the valley. By such alternate expansions and contractions the glacier moves gradually from the top to the bottom of its course.

That variations of temperature do take place in a glacier cannot be doubted, whatever be the condition in which it lies. This granted, the fact that it should move in the way described appears to me no more surprising than that the sheets of lead on which Canon Moseley made his well known experiments did so move; and that the motion thus produced is of the character which answers to all the facts of the case so far as they are at present known, can, I believe, be established.

The controversy occasioned by Canon Moseley's articles was unfortunately terminated by his illness and death, before the matter had been fully cleared up. The main objections urged to his theory were two. The first was that a glacier is not one continuous body (as assumed by Canon Moseley in his mathematical investigation), but is broken up into many parts by crevasses. But in the first place, the assumption above mentioned is merely one of convenience, and not in the least necessary to the theory. A detached piece of ice would move in the same way as a glacier, or as the sheet of lead did in Canon Moseley's experiments. Secondly, if a glacier is anywhere divided in its whole thickness by a crevasse, this is absolutely fatal to the gravitation theories, since there can be no pressure between the portions above and below this division. The only possible explanation of crevasses on these theories is that they are due to the glacier bending over a convex part of its bed. In that case the bottom half will be in compression, and only the top half in tension, so that the crevasse cannot possibly extend more than half way through the thickness.

The second objection was that the conductivity of ice is low; hence the effect of the heat would be confined to the layers near the surface, and could not account for the motion of the glacier as a whole. This objection does not seem to be confirmed by careful reflection upon the way in which such forces act. Let us suppose a glacier 100 feet deep, of which each successive foot expands and contracts alike throughout, but adheres with a definite shearing resistance to the layers above and below. Let there be a rise in temperature which does not extend beyond the uppermost 10 feet. This layer will expand, and if it were free would expand to the full amount due to the increase in temperature. But its lower surface is not free. In expanding it will therefore drag the next layer after it, or in other words will cause it to expand also. The amount of expansion, however, will not be so great, because there will be a certain shearing extension at the plane of division between the two. The second layer will similarly cause an expansion in the third, and so on to the bottom. In consequence the energy which would all have been exerted on a top layer, had that been free, will be distributed over the whole of the layers; and the extension of the top layers will of course be much smaller than it otherwise would have been. Should the temperature then remain constant, the layers will retain their position, and adapt themselves to the new circumstances. If the temperature falls, the layers will contract, but from the now opposing effect of gravity they will not return to their original position. The top layer, which has extended furthest, will be the furthest below its original position: the second layer next, and so on. If we suppose the layers to be indefinitely thin, we have the condition of things in an actual glacier. The ice in any vertical section will, on the whole, move down the slope, but the top will move faster than the middle, and the middle than the bottom, exactly as it is known to do. The same holds with regard to a horizontal section. At the sides the ice will be held back, not only by the friction, but also by the protuberances of the rock, which compel the ice to shear over them. Hence the velocity there will be retarded, and will be less than that in the middle, which is comparatively free.

A more important objection remains to be considered, which is this: On the present theory, the motion at any point on the surface of a glacier will be not continuous, but oscillating alternately downward and upward, and the net distance by which it has descended, say, in a day, will be a mere fraction of the total distance through which it has moved in that period. If so, this alternate motion ought to have been noticed in the various observations which have been made upon glaciers, and this does not appear to have been the case. But in reply to this it may be remarked that most of the observations have only given the net movement of points on the glacier during intervals of a day or more, and therefore would not show the oscillations. Again, such observations have always been at points near the end of a glacier. Now the variations in temperature of a glacier will be very different at different parts, and the motion of the end of the glacier will, to a great extent, show the average result of these different advances and retreats in different parts of the higher regions. This average result will, of course, be a steady progression down the valley, and the oscillatory movement at the end of the glacier may be so much masked by this as not to be readily observable. Lastly, it may be suggested as possible that a certain amount of expansion by heat may have the effect of giving a *set* to ice, so that it does not return to its original length when brought back to the same temperature. If this be so, the oscillations would be much less marked, and at the end of the glacier would probably be indistinguishable.

I may now draw attention to some phenomena of glacier action, which are explained by the heat theory, but which do not seem explicable on the gravitation theory.

(1) It is well known that glaciers, when they emerge from a narrow gorge into a comparatively wide valley, spread out into a fan shape. The Rhone glacier is a well-known instance. A still better one is a small glacier in Norway, mentioned by

* Paper read at the Royal Society, June 15, 1882.

* Another evidence against pressure from behind as a cause of motion is furnished by the very small size of many glaciers. Some of these, notably those of the class called "glaciers remanés," are only a few hundred yards long, and cannot be many feet deep.

Prof. Sexa, which spreads out to five or six times its previous width. Now, the effect of gravity, acting on a mass as a whole, is to carry it in one single direction, that of the steepest slope. The only way in which gravity can produce such a spreading out is by the parts of the glacier shearing over each other in the manner of a viscous solid. But the phenomena of ice cliffs, as mentioned above, show that ice does not spread from this cause, so that the fact seems impossible to explain by gravitation alone. On the heat theory it is, of course, perfectly easy: the expansion and contraction will take place in all directions where there is freedom to move.

(2) Connected with this phenomenon is that of the longitudinal crevasses seen near the edges of glaciers, and particularly where they spread out in the manner just described. Now, on the gravitation theory, as remarked above, the only possible explanation of a crevasse is that the ice is bending over a convex surface, and that its upper part is thus placed in a state of tension, under which it breaks. Since, on the gravitation theory, every part of a glacier is exposed to a severe pressure from behind, this explanation does not fit very well even for transverse crevasses; but to longitudinal crevasses it is clearly inapplicable, since the bottom of a valley is seldom or never convex in the direction of its width. On the heat theory the explanation is simple. We may suppose the heat energy communicated per square foot of surface to be about the same, whether near the middle or edge of a glacier. This energy is expended in producing an expansion throughout the whole thickness of the glacier, as described above. Hence the smaller this thickness, the greater will be the amount of expansion, and the greater therefore the net motion which results. Hence the thinner parts of a glacier will always be tending to tear themselves off from the thicker, and thus longitudinal crevasses will frequently be found.

(3) The striæ which are so marked a feature of glacier-worn rocks become more easily explained on this theory. I have seen such striæ, even in the hard hypersthene of Skye, which were a considerable fraction of an inch in depth. When we consider the enormous force necessary to plow out such a furrow in hard rock, it is almost impossible to believe that it was done by the simple passage over it, once for all, of a stone embedded in the ice. If, however, the stone descended by a series of oscillations, so that it passed many times over the same spot, this difficulty is greatly lessened.

(4) In conclusion I may point out that the advocates of the gravitation theory are bound to explain what becomes of the heat energy which is poured into a glacier. When the sun is shining this radiant energy is always very large, although the temperature of the air may be low. In such cases the glacier does not melt, it is perfectly clear that it must expand, as any other solid must expand under the action of heat. If so, it seems unreasonable not to hold that the gradual descent by alternate expansion and contraction must follow, as it is known to follow in the case of other materials.

On the subject of the motion of Arctic ice, Dr Rae, F R S., has kindly permitted the publication of the following particulars:

"When in Greenland, in the autumn of 1866, I was ice-bound at the head of one of the fiords, and slept a couple of nights at an Eskimo's house. A glacier about half a mile distant was then in full activity, the movement of which might, I believe, have been as visible to the eye as it certainly was audible to the ear.

"My own idea is that Arctic glaciers must have a downward motion more or less during the whole year, summer and winter. I believe the alternation of heat and cold—or I should rather say, of temperature—would of itself cause motion, especially near the upper surface.

"We know that ice 2 or 3 feet or more thick contracts very considerably in a very few hours by a sudden fall of 15 or 20 degrees of temperature. I have found cracks in Lake Winnipeg 3 or 4 feet wide formed by this cause during a single night, almost stopping our sledge journey. This gap soon freezes up. Then the weather gets milder, the ice expands and with the new additional formation is too large for the lake, and is forced up into ridges. This process goes on at every 'cold snap'* alternating with milder weather. Now, supposing a glacier for 10 or more feet of its depth contracts by cold, as lake ice is known to do, it will get a series of probably in its longest axis, say from inland seaward; the first snowdrift will fill up these cracks or some of them, and this filling up will to some extent perform the same office as the freezing of the cracks in the lakes. The longitudinal extent of the glacier will be increased. A snow storm always brings milder weather, which would expand the glacier, but as this expansion would naturally tend downhill, instead of up, the whole motion would be downward. But even if the cracks I mention did not take place, the contraction by cold would pull the ice downhill, not up, while the expansion by increase of temperature would tend to *push* the glacier downhill, so that these opposite actions would produce similar effects in moving the glacier, or such part of it as could be acted upon by external temperature, downward.

"I may also add that when a crack, however slight, is formed by contraction, the cold is admitted into the body of the glacier, and increases the contracting power or influence."

BISMUTH BRONZE.

A NEW metallic alloy, which the inventor calls bismuth bronze has been recently patented by Mr. James Webster, of Solihull, as an alloy specially suitable for use in sea-water, for telegraph and music wires, and for domestic articles. The composition varies slightly with the purpose for which the bronze is to be used, but in all cases it will be seen that the proportion of bismuth is very small. For a hard alloy the patentee takes one part of bismuth and sixteen parts of tin, both by weight, and having melted them, mixes them thoroughly in a suitable vessel as a separate or preliminary alloy. For a hard bismuth bronze, he then takes sixty-nine parts of copper, twenty-one parts spelter, nine parts nickel, and one part of the alloy of bismuth and tin. The metals are melted in a suitable furnace or crucible, and thoroughly mixed, when, while in the molten state, they are run into moulds of any convenient shape or form, for future use. This bismuth bronze is a hard, tough, and sonorous metallic alloy, which, by preference, the patentee uses in the manufacture of screw-propeller blades, shafts, tubes, and other appliances employed partially or constantly in sea-water; it being specially prepared and suited to withstand the destructive action of the hydrochloric acid of salt water. In consequence of its toughness, it is well suited for telegraph wires, and other similar purposes where much strain has to be borne by the wires. From its sonorous quality, it is well adapted for piano and other music wires, also for any similar purposes to the preceding.

For domestic utensils and other articles, generally exposed to atmospheric influence, the patentee prefers to slightly vary the previous composition, thus: One part of bismuth, one part of aluminum, and fifteen parts of tin are melted together to form the separate or preliminary alloy, which is added in the proportion of one per cent. to the above described alloy of copper, spelter, and nickel. The resulting bronze forms a durable, bright, and hard metallic alloy suited for the manufacture of spoons, forks, knives, dish-covers, kettles, tea-pots, jugs, and numerous other utensils or articles exposed to atmospheric influence. These alloys are said to resist oxidation, to polish well and easily, and to keep their color well. The patentee claims the use of bismuth in making bronze, but does not restrict himself to the precise quantity of each of the metals above given, as they may be slightly varied in relative quantity or weight, according to the special quality of the bronze required, and the uses to which it is intended to be applied, without departing from the main characteristics of the invention.

EXPLOSIVE ALLOYS OF ZINC.

A LONG and interesting research carried on by H. Sainte-Claire Deville and H. Debray on this subject has, since the death of the former, been completed by Debray. The compounds of osmium cannot be separated mechanically. If one endeavors to break them up in a steel mortar, the pieces of osmium-iridium penetrate the steel but do not break. If we melt the alloy with from twenty-five to thirty times its weight of zinc, and heat the mixture for some hours at a red heat, and then more strongly to volatilize the zinc, there remains a spongy, very friable mass, which is readily and completely attacked by a mixture of barium nitrate and barium peroxide—a material employed by the author for the oxidation of osmium and iridium, and is then easily soluble in acids.

As baryta is afterward easily separated from solutions, the analysis of osmium-iridium alloys is rendered a very easy matter in this manner. What part the zinc plays in this reaction cannot be explained by the researches hitherto made; but the carrying out of the experiment is in this wise. The zinc is melted at a red heat, and the osmium-iridium is then let down into it. A great development of heat is the result.

The fused mass is to be kept at the temperature for from five to six hours, and after it has become cold the regulus is to be treated with dilute hydrochloric acid, which dissolves the zinc easily, while a black graphite-like mass remains, containing all the noble metals of the osmium-iridium alloy. The greater part of the iron present dissolves with the zinc, but a considerable quantity of the zinc remains combined with the two noble metals, and this quantity it is not possible to remove from them by any further treatment with acid. The residue, well washed and dried at 100 deg., evolves a feeble smell of osmic acid. When heated to 300 deg. it rapidly takes fire, almost with explosion, and gives off a considerable quantity of smoke, which consists of zinc oxide and osmic acid.

As this combustion of the alloy also takes place *in vacuo* without any disengagement of gas and without any formation of zinc oxide or osmic acid, it must be assumed that at 300 deg. a great change of condition, involving a great evolution of heat, must take place. In the air these changes are immediately accompanied by the combustion which increases the development of heat. This residue is only partly attacked by concentrated nitric acid and *aqua regia;* it is readily and completely oxidized if placed in a crucible with a fused mixture of potash and potash nitrate. In a similar way it is oxidized when heated with a mixture of anhydrous baryta and barium nitrate.

Osmium simply dissolves in zinc, and after testing the fused mass with acid it remains unchanged. Palladium and platinum yield alloys which when heated *in vacuo* form no isomeric modification. Rhodium, on the other hand, and especially iridium and ruthenium, combine with the zinc with a lively development of heat, and if these compounds are afterward treated with hydrochloric acid, there remain residues which, when heated to 300 deg., pass over into an isomeric modification, the passing over being accompanied with a great evolution of heat. Before the development of the heat the black residues are more or less acted upon by *aqua regia*; after the development they have lost this property, and possess a metallic appearance.

The thermal phenomenon, which accompanies the change of condition of the residue containing iridium, is so distinctly shown that it can be used to discover the presence of small quantities of iridium—say from 1 to 2 per cent.—in platinum. To do this the platinum to be examined has to be melted in zinc, the alloy to be treated with dilute hydrochloric acid, the dried residue to be heated in a platinum dish to 300 deg., when iridium, if present, glows at different points of the mass. Ruthenium and rhodium exhibit similar appearances. Osmium is then the only platinum metal which, when fused with zinc, does not retain some of it, and thus the action of the zinc on the osmium-iridium alloy is readily explained. If the heat which is developed by the combination of iridium with zinc is greater than that developed by the combination of iridium and osmium, then, according to the law of thermo-chemistry, the compound of osmium and iridium will be destroyed by zinc. Osmium dissolves and can crystallize in the excess of the other metal. Iridium and the remaining metals, on the other hand, are in combination with the zinc. The residue of the action of hydrochloric acid on the alloy contains an excess of zinc from the above-mentioned explosive compound.

MANUFACTURE OF LUMINOUS PAPER.

A PATENT has been granted in England for the use of phosphorescent substance in the manufacture of paper in such way as to produce paper that will when seen in a dark place, after exposure to light, appear distinctly luminous, and will maintain its luminosity for a considerable time. Such paper will be serviceable for lighting up passages and chambers, especially water closets and other places wherein only moderate light is required. The inventor uses what is known to chemists as sulphide of calcium—a substance that is sold commonly as Puzey's luminous powder. This the inventor, according to his specification, either sprinkles over the paper pulp when in the paper maker's chest, mixing the pulp and powder thoroughly by stirring, or he makes with the luminous powder a paste by adding to it twice its weight of boiling water, and allows the mixture to stand for a period of about 36 hours, but stirring it at intervals during that period. He then pours off any supernatant water and thus obtains as a product a paste he terms luminous water paste. He mixes this luminous water paste with paper pulp in the condition known in the trade as three-quarter stuff, so that the comparatively heavy luminous substance shall not be liable to settle, and work out when the material is passing through the machine cylinders. Thus in carrying out this invention, to 180 lb. of ordinary paper pulp known as three-quarter stuff he adds 140 lb. of luminous water paste such as is above referred to; with these he mixes a small percentage of salts or ultramarine if white paper is desired, and he stirs the compound well in the paper maker's chest; then he rolls it out in the ordinary way between cylinders, or treats it with hand sieves, until it assumes the condition known to paper makers as water-leaf. This water-leaf is then tub-sized in the way usually practiced by paper makers using size such as ordinarily employed by them. When desired the inventor imparts to the size a waterproof character by adding to it a small percentage of tannin or bichromate of ammonia or other waterproofing substance.

* "Cold snap," an American term meaning a rather sudden increase of cold.

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